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**BUREAU OF MEDICINE AND SURGERY  
NAVY DEPARTMENT, WASHINGTON, D.C.  
MARCH, 1946**

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TABLE OF CONTENTS

INTRODUCTION. . . . .	1
MOSQUITOES OF MEDICAL IMPORTANCE:	
<u>Anopheles</u> ( <u>Anopheles</u> ) <u>barbirostris barbirostris</u> . . . . .	3
<u>Anopheles</u> ( <u>Anopheles</u> ) <u>hyrcanus nigerrimus</u> . . . . .	5
<u>Anopheles</u> ( <u>Anopheles</u> ) <u>hyrcanus sinensis</u> . . . . .	7
<u>Anopheles</u> ( <u>Anopheles</u> ) <u>umbrosus</u> . . . . .	9
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>aconitus</u> . . . . .	11
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>annularis</u> . . . . .	13
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>culicifacies</u> . . . . .	15
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>farauti</u> . . . . .	17
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>jeyporiensis candidiensis</u> . . . . .	19
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>kochi</u> . . . . .	21
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>maculatus</u> . . . . .	23
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>minimus</u> (including <u>flavirostris</u> ). . . . .	25
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>philippinensis</u> . . . . .	27
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>punctulatus</u> . . . . .	29
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>subpictus</u> . . . . .	31
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>sundaicus</u> . . . . .	33
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>tessellatus</u> . . . . .	35
<u>Anopheles</u> ( <u>Myzomyia</u> ) <u>vagus vagus</u> . . . . .	37
<u>Aedes</u> ( <u>Finlaya</u> ) <u>togoi</u> . . . . .	39
<u>Aedes</u> ( <u>Stegomyia</u> ) <u>aegypti</u> . . . . .	41
<u>Aedes</u> ( <u>Stegomyia</u> ) <u>albopictus</u> . . . . .	43
<u>Aedes</u> ( <u>Stegomyia</u> ) <u>hebrideus</u> . . . . .	45
<u>Aedes</u> ( <u>Stegomyia</u> ) <u>pseudoscutellaris</u> . . . . .	47
<u>Aedes</u> ( <u>Stegomyia</u> ) <u>tongae</u> . . . . .	47
<u>Culex</u> ( <u>Culex</u> ) <u>pipiens pallens</u> . . . . .	49
<u>Culex</u> ( <u>Culex</u> ) <u>quinquefasciatus</u> . . . . .	49
<u>Mansonia</u> ( <u>Mansonioides</u> ) <u>annulifera</u> . . . . .	51
<u>Mansonia</u> ( <u>Mansonioides</u> ) <u>indiana</u> . . . . .	53
<u>Mansonia</u> ( <u>Mansonioides</u> ) <u>longipalpis</u> . . . . .	51
<u>Mansonia</u> ( <u>Mansonioides</u> ) <u>uniformis</u> . . . . .	53
BIBLIOGRAPHY . . . . .	54

## INTRODUCTION

The purpose of this paper has been to present as an atlas a compilation of data relative to the distribution of mosquitoes of medical importance in the Pacific Area. In addition, a brief discussion of pertinent information concerning systematics, bionomics, and disease transmission data has been summarized as a further aid to military forces in the field.

The following monographs were frequently consulted in writing the text: Swellengrebel and Rodenwaldt, Die Anophelen von Niederlandisch-Ostindien; Lee and Woodhill, The Anopheline Mosquitoes of the Australasian Region; Simmons and Aitken, The Anopheline Mosquitoes of the Northern Half of the Western Hemisphere and of the Philippine Islands; Russell, Rozeboom and Stone, Keys to the Anopheline Mosquitoes of the World; Christophers, The Fauna of British India including Ceylon and Burma; Gater, Aids to the Identification of the Anopheline Imagines in Malaya; Barruad, Fauna of British India; and Bonne-Wepster and Brug, Nederlandsch-Indische Culicinen.

Distribution records were compiled from reports in the literature and from collection data of specimens examined by the authors. Literature records are indicated on the maps by an open circle, and in the reference source by a number of the bibliography. Data from specimens examined are indicated on the maps by a closed circle, and in the reference source by the initials of the institution in which specimens are deposited. The following collections were studied: United States National Museum (U.S.N.M.), Washington, D. C.; Johns Hopkins (J.H.), Baltimore, Maryland; and the Museum of Comparative Zoology (M.C.Z.), Cambridge, Massachusetts. Some distribution records have been derived from classified intelligence reports which are not included in the bibliography.

This atlas was prepared, in addition to the assistance and facilities afforded by the U. S. National Museum, by Lieut. D. S. Farner, Lieut. R. J. Dicke, G. Sweet, Y1c, L. Isenhour, Y3c, and T. Y. Hsiao, Entomologist.

Bureau of Medicine and Surgery  
Preventive Medicine Division  
Communicable Diseases Control Section



**Systematic notes.** *A. barbirostris* is closely related to *bancroftii* and has been frequently confused with *barbumbrosus*. In *bancroftii* adults the femora and tibia are distinctly speckled with white scales which are absent in *barbirostris*. The stigmal club of the spiracular apparatus in *bancroftii* larvae is absent in *barbirostris*. Adults of *barbirostris* and *barbumbrosus* are very difficult to separate. In the latter species the apical pale spot of the wing fringe (extending from vein 2 to 4) is usually interrupted by a dark spot. This apical pale fringe spot is confined in *barbirostris* to a small area at vein 3. The outer anterior clypeal hairs of *barbirostris* larvae number 50 or more branches, while those of *barbumbrosus* usually number from 11 to 22 branches. Intermediate larval forms occur, and in some areas as in the Philippines the status of these species is uncertain. Lee and Woodhill (190) reviewed Venhuis' discussion of a *barbirostris* subspecies in Celebes biologically and to some extent morphologically distinct from the typical species. The status of this form is uncertain although its discussion does indicate that further detailed study of the *barbirostris* group is necessary.

**Bionomics.** Larvae have been collected from a wide variety of situations, although *barbirostris* appears to prefer the shaded clear water of streams, rivers, and large vegetated ponds and pools formed by springs or dams. In Malaya rice fields are the preferred breeding site, and in India the vegetated margins of lakes, swamps and sluggish rivers. Other breeding sites listed were flowing irrigation ditches and canals, borrow pits, wells, and other stagnated situations. Clear and fresh water sites were most generally encountered, although in the Netherlands Indies, Swellengrebel and Rodenwaldt (285) frequently listed exposed or shaded, turbid and stagnate situations as well. On one occasion Russell (254) found larvae of this species in a salt marsh in the Philippines.

In India, Christophers (67) considered *barbirostris* a wild species, but noted that it became more domestic as its range progressed eastward. Adults frequently fly during cloudy days or in jungle shade. A flight range of 400 to 600 m. for stained specimens was observed by Russell and Santiago (261) in the Philippines. Although adults enter habitations for a blood meal, they seldom remain during the day. Russell (253) collected resting adults along the eroded undercut banks of streams, from sides of a shaded stone wall, and under an uninhabited building.

Although adults will attack man readily, in most areas the females are zoophilic in their feeding habits. Mesnard and Toumanoff (216) reported that only 6 per cent of blooded females collected in Cochinchina and Indochina contained human blood. In Malaya, Soesilo (275) observed that where cattle were abundant only 14 per cent of blooded females contained human blood as compared to 31 per cent where cattle were scarce.

**Relation to disease.** A low susceptibility to experimental infection was demonstrated for *barbirostris*, the rates ranging from 3.8 to 20 per cent for *Plasmodium vivax* and *P. falciparum*. In general this

species is not considered an important vector of malaria except where it occurs in great numbers or serves as an accessory during an epidemic. In certain areas of Malaya, however, Soesilo (275) and Weyer (335) considered *barbirostris* as the chief vector. Soesilo reported that of 914 specimens collected from houses near the Kinta River swamps, 3 per cent were infected. According to Gater (125) natural infection rates for specimens collected in the Malay States ranged from 0.98 per cent to 7.5 per cent, with a mean average of 1.43 per cent for a total of 2515 dissections. Covell (75) cited an infection rate of 0.7 per cent for 141 dissections. Machsoes (205) found that of 1,291 specimens collected in the Celebes, 5.8 per cent were naturally infected. The compilation of data by Swellengrebel and Rodenwaldt (285) for Sumatra listed an average infection of 0.43 per cent for a total of 922 specimens. However, on the Island of Banka adjacent to Sumatra, Walch and Soesilo (332) reported 5 per cent natural infections of 121 specimens. In the Philippines a total of 1094 dissections by Manalang (208) were negative, and in all other areas outside of Malaya, Celebes, and Sumatra, *barbirostris* appears to be of little importance.

Prawirohardjo (240) reported the development of infectious larvae of *Wuchereria bancrofti* during experimental infections, and concluded that *barbirostris* was a likely vector. Brug (50, 51) in addition demonstrated that it was the most important vector of *W. malayi* at Kalawara, Celebes with natural infection rates of 2.1 to 8.1 per cent.

**Distribution.** Confined in its distribution to the Oriental Region, *barbirostris* ranges from India, Burma (including the Andaman Islands) Siam, and Tonkin, Indochina into China (including Hainan) at Yunnan Province, with scattered records along the coast northward to Chekiang Province. Southward this species extends throughout the Malay Peninsula and Archipelago to Timor and Kisar including Borneo, Celebes and the Philippines. According to Lee and Woodhill (190) records for the Moluccas, Soela, Boeroe, Ceram and other adjacent small islands as reported by Swellengrebel and Rodenwaldt (285) are confused with *barbumbrosus*. Records from Dutch New Guinea are also probably *barbumbrosus*, and the exact status of *barbirostris* in Celebes and adjacent islands is uncertain.

#### Sources of Distribution Records.

Burma: 67, 100.  
China: 61, 108, 109, 195, 200, 243, 245, 288, 336, 343, 345.  
India: 67, U.S.N.M.  
Indochina: 97, 118, 119, 123, 127, 128, 210, 211, 218, 313, 317, 318.  
Malay Archipelago: 49, 50, 51, 53, 131, 165, 205, 226, 240, 263, 280, 285, 328, 330, 334, U.S.N.M.  
Malaya: 19, 25, 125, 133, 143, U.S.N.M., J.H.  
Philippine Islands: 144, 254, U.S.N.M.  
Siam: 19, 25, 30, 59, 278, U.S.N.M., J.H.



ANOPHELES (ANOPHELES) HYRCANUS NIGERRIMUS Giles, 1900

Synonymy. Myzorhynchus argyropus Swellengrebel 1914; Anopheles hyrcanus sinensis Wiedemann 1828 of authors in part.

Systematic notes. Throughout its range, and in the Netherlands Indies in particular, nigerrimus has been confused with sinensis. The relationship of nigerrimus to sinensis is discussed under the latter species. In the adult, the broad tarsal pale bands of nigerrimus distinguish it from lesteri and pseudosinensis of the Philippines. This pale banding is often extensive as in the form argyropus, and nigerrimus was therefore considered of species rank by Bohart (33) rather than as a subspecies of hyrcanus in which the tarsal bands are comparatively very narrow. The larval mesothoracic hair V of nigerrimus has six to eight slender curving branches as compared to three or four straight branches in lesteri and pseudosinensis.

Bionomics. The larvae of nigerrimus are found most generally in rice fields, and exposed, slowly-flowing irrigation ditches. Other breeding sites reported were slowly-moving streams, stagnant ditches and pools, impounded water, lakes, tanks, swamps, and borrow pits. These situations were either exposed to sunlight or shaded. Clear, open water frequently associated with aquatic vegetation apparently is preferred although collections were made in muddy and fouled situations. According to Christophers (67) larvae were found in brackish or salt water.

Adults are seldom collected or found resting within habitations or cattle sheds. It is considered a wild species, although the females feed readily on man and domestic animals. At Bengal, India, Timbres (304) found that nigerrimus was primarily zoophilic in its feeding habits. Overbeek and Stoker (234), however, described the species as anthropophilic and domestic in certain areas of the Netherlands East Indies.

Relation to disease. Data concerning natural infections of nigerrimus with plasmodia are incomplete and frequently confused with sinensis. In the Netherlands Indies and especially Sumatra, it is considered an important vector of malaria. During an epidemic in Sumatra, Walch

(331) reported 12 per cent natural infections of 3,638 specimens examined, and Walch and Soesilo (332) at a later period reported 1.7 per cent natural infections of 1998 specimens. According to a compilation of data by Swellengrebel and Rodenwaldt (285), a total of 22,974 specimens collected in Sumatra were examined by other workers with an average natural infection of 0.95 per cent. Infection rates ranged from 0.11 per cent to 6.55 per cent. In Java, Soesilo (274) found 2.1 per cent infections of 334 specimens, and Schüffner and Swellengrebel de Graaf (285) 0.37 per cent of 273. In other areas nigerrimus is not considered a serious vector. Hodgkin (143), however, found 4.5 per cent midgut and 2.5 per cent salivary gland infections of 200 specimens collected in Malaya. At Tonkin, Indochina, Marneffe et al (211) reported 1.43 per cent natural infections of 70 dissections, and Gaschen (120) 1.5 per cent of 68.

According to Neveu-Lemaire (228) the complete development of Wuchereria bancrofti was observed in this species.

Distribution. A. hyrcanus nigerrimus is confined to the Oriental Region. Its distribution in China, including Hainan, does not occur north of about 25° N. latitude with the exception of one collection at Nanking (334). From India and Burma it ranges southward through Siam, Indochina, the Malay Peninsula to Sumatra and Java, including the Philippine Islands and one recorded collection in Borneo. Data concerning the distribution of nigerrimus particularly in the Netherlands Indies is incomplete since this species may be confused with records for sinensis.

Sources of Distribution Records.

Burma: 67, 100.  
China: 61, 109, 195, 200, 243, 288, 334, 343.  
India: 67, U.S.N.M.  
Indochina: 18, 42, 122, 123, 126, 127, 211.  
Malay Archipelago: 285, 334, U.S.N.M.  
Malaya: 143.  
Philippine Islands: 144, 254, U.S.N.M.  
Siam: 30, 59, 278, J.H.



ANOPHELES (ANOPHELES) HYRCANUS SINENSIS Wiedemann, 1828

Synonymy. Anopheles sinensis Wiedemann 1828; A. plumiger Dönitz 1901; A. jesoensis Tsuzuki 1901; A. hyrcanus Pallas 1771 of authors in part.

Systematic notes. Records concerning sinensis have been considerably confused with other subspecies of hyrcanus as well as with the typical species. Many authors made no attempt to differentiate these, and have considered the subspecies merely as the hyrcanus group. In the Netherlands Indies, Swellengrebel and Rodenwaldt (285) list six varieties of hyrcanus, and the references of Dutch authors (Venhuis (326) to hyrcanus "X" (supposedly synonymous with sinensis and nigerrimus) further complicates the systematics of this species. Russian references to the hyrcanus of South Siberia (presumably sinensis), and records in North Manchuria may be confused with other subspecies as well.

Throughout the Netherlands Indies, sinensis is largely confused with and may actually be identical to nigerrimus. Adults are readily separable by the ornamentation of the tarsi. In sinensis, the tarsal pale bands are very narrow and tarsi IV and V are unbanded. The tarsal pale banding of nigerrimus, however, is broad and often extensive, with basal pale bands on segments IV and V. In the larvae, the palmate hair leaflets on segments III to VI are less densely and more evenly pigmented in sinensis leaving only the tips of the leaflets clear, while in nigerrimus the leaflets are clear for as much as one-third of their entire length. According to Baisas and Hu (24), the sinensis of the Philippines has been replaced and separated into the subspecies lesteri and pseudosinensis.

Bionomics. The preferred breeding sites for sinensis are rice fields and pools. Larvae were also collected from swamps, borrow pits, cisterns, irrigation ditches, and sometimes along the margins of lakes and slow-moving streams. In China, larvae commonly breed in stagnated water, and Crook (76) listed as a breeding site old manure pits containing rain water. At Okinawa, larvae were frequently encountered in small, clear pools. Breeding seldom occurred in turbulent water in the Netherlands Indies according to Swellengrebel and Rodenwaldt (285), and only one record for brackish water was observed. Considered as a group, the hyrcanus species were regarded in the Netherlands Indies as typical marsh mosquitoes, and breeding was observed to increase rapidly with clearing or cultivation of jungle areas.

In China, sinensis appears to be primarily zoophilic in its feeding habits. Toumanoff (313) reported that 98 per cent of 365 blooded specimens collected in the close proximity to man contained human blood as compared to only 0.9 per cent of 1239 blooded females collected from stables and pens. Hu and Yu (155, 156), however, found that a comparatively small per cent of an equal number of blooded females contained human blood although collected from both stables and human habitation (4.8 percent and 8.2 percent respectively). Reports of other authors from China and Indochina range from 7.1 per cent to 30.4 per cent of blooded females containing human blood with a mean of 21.5 per cent for 2,456 specimens dissected.

Relation to disease. According to a summary of data by Simmons and Aitken (270), sinensis has been experimentally infected with Plasmodium. Experimental infections ranged from 17.3 per cent to 43.8 per cent for vivax, with single records of 3.4 per cent for falciparum and 5.8 per cent for malariae.

At Tonkin, Indochina, sinensis is generally considered of secondary importance as a vector of malaria. Toumanoff (307) reported that of 2,453 dissections, all were negative. Reports of natural infections

by six authors for Tonkin varied from 1.55 per cent to 4.97 per cent with a mean infection rate of 3.1 per cent for a total of 2,460 dissections. In Malaya, Hodgkin (143) reported 3 per cent, midgut and 2 per cent salivary gland infections of 109 specimens, and Soesilo (274) 0.6 per cent of 176. Records for the Netherlands Indies are questionable, and are probably referable to nigerrimus. For Yunnan Province, China, Chang (62) reported natural infections of 2.6 per cent, Robertson (245) 3.5 per cent, and Yao et al (345) 0.06 per cent with 1,695 dissections. In all other areas of South China, natural infection rates ranged from negative to 7.0 per cent with a mean of 0.83 per cent for a total of 4,312 dissections. At Nanking, Yao and Wu (344) reported only 0.09 per cent natural infections of 6,455 specimens, and Khaw and Kan (167) 0.41 per cent of 1,200 specimens. Feng (108) reported natural infections of 0.43 per cent for 464 specimens collected in the Yangtze Valley. In South China, the status of sinensis as an important vector is uncertain, especially in view of its zoophilic feeding habits. However, in Central and North China it is the only probable vector of malaria, as well as in Manchuria wherever maculipennis does not occur.

Data summarized by Yao (342) for China as hyrcanus are probably referable to sinensis. The mean average rate of natural infections was 0.28 per cent for a total of 16,199 dissections. Ramsay (241) and Strickland (281) reported that all were negative for plasmodium of 7,218 hyrcanus collected at Assam, India. Considering all collections of hyrcanus species by many authors throughout the Far East, Toumanoff (315) listed 44,555 dissections with a natural infection rate of 0.57 per cent.

Sinensis may be an important vector of filariasis in China. Hu (148, 150) reported that 96 per cent of sinensis developed infective larvae of Wuchereria bancrofti experimentally, and 3.6 per cent of 87 specimens collected at Shanghai were naturally infected. Natural filarial infections were also reported by Yamada (341) and Feng (102, 107). Feng (105) observed the normal development of W. malayi in this species.

Distribution. A. hyrcanus sinensis is an Oriental species extending into the Palearctic Region, with its center of distribution in China including Hainan and Formosa. Its range includes Korea, Japan (and the Ryukyu Islands), Manchuria and probably extends northward into Siberia. Southward of China, it ranges from eastern India (Annam), Burma, Siam, and Tonkin, Indochina through the Malay Peninsula to Sumatra, Borneo and Java. Records for the Netherlands Indies, however, are questionable and may be confused with nigerrimus. The entire range for Indochina, China, and Manchuria is uncertain.

Sources of Distribution Records.

China: 61, 62, 76, 104, 106, 108, 109, 139, 141, 156, 161, 162, 163, 167, 200, 204, 245, 278, 288, 313, 320, 337, 338, 342, 343, 344, 345, U.S.N.M.  
India: U.S.N.M.  
Indochina: 63, 97, 118, 119, 123, 126, 127, 128, 192, 210, 211, 313, 317, 318.  
Japanese Archipelago: 229, 231, 232, 339, U.S.N.M., M.C.Z.  
Korea: 178, 339.  
Malay Archipelago: 49, 165, 226, 263, 279, 285.  
Malaya: 133, 143, U.S.N.M., J.H.  
Manchuria: 65, 66, 109.  
Siam: 25, 278.  
Siberia: 56, 79, 225, 267, 268.



ANOPHELES (ANOPHELES) UMBROSUS Theobald, 1903

Systematic notes. The adults of umbrosus are very similar to barbirostris. The absence in umbrosus of a scale tuft on abdominal sternite VII, and the shaggy scaled palpi of barbirostris serve to distinguish these species. As in atratypes, abdominal palmate hairs of the larvae are not well developed and are represented by branched hairs. The Philippine form closely related to umbrosus has been considered a distinct species gateri by Baisas (23). According to Gater (125) umbrosus represents a variable group in which considerable revision is necessary.

Bionomics. Essentially a forest species, umbrosus breeds principally in shaded stagnant jungle pools and morasses, and pockets of water between roots of trees. Larval breeding has also been reported in brackish water pools along the fringe of mangrove swamps. Other breeding sites reported were sluggish streams, springs, open swamps, and a deep lake. Breeding is common in water discolored by decaying vegetation and peat, although fresh spring water to muddy and brackish situations were reported. The larvae prefer but are not dependent upon shaded sites.

Adults have been collected from houses bordering the jungle and are frequently encountered in densely shaded jungle. The females feed on man readily and persistently although their blood preference is uncertain. Overbeek and Stoker (234) reported that umbrosus was strongly anthropophilic in the Netherlands Indies. The adults are considered strong fliers.

Relation to disease. The experimental infection of umbrosus with Plasmodium vivax and P. falciparum ranged from 4.8 per cent to 39 per

cent, and susceptibility to infection was said to be low. Stanton (276) considered umbrosus as a doubtful vector of malaria in Malaya, although Overbeek and Stoker (234) concluded that it was the most dangerous species along the coastal plains. According to Covell (75), a mean average of 2.28 per cent natural infections for a total of 307 dissections were reported from this area. In the Netherlands Indies umbrosus may be of importance as a vector. Weyer (335) cited 1,255 dissections for the entire region with 0.96 per cent infection. Covell (75) listed 0.8 per cent infection of 130 specimens in Borneo, and Swellengrebel and Rodenwaldt (285) one infection of 43 dissections in Sumatra. Walch and Soesilo (332) reported six natural infections (4.96 per cent) of 121 specimens collected at Banka.

Distribution. The distribution of umbrosus is limited in the Oriental Region to Malaya, the southern portion of Indochina (Cochinchina), Sumatra, Java, Borneo, and Celebes. In India, collections were reported only from Assam and the Andaman Islands. Christophers (67) also listed Tonkin, Indochina, and Lee and Woodhill (190) Burma and Siam. Its distribution in these regions is likely although uncertain. At Boeroe, the species extends into the Australasian Region. The umbrosus of Philippine authors is considered a distinct species gateri.

Sources of Distribution Records.

India: 67.

Indochina: 96, 221.

Malay Archipelago: 9, 53, 226, 234, 263, 280, 285, 330, 334.

Malaya: 133, J.H.

Melanesia: 285.



ANOPHELES (MYZOMYIA) ACONITUS Dönitz, 1902

Synonymy. Myzomyia albirostris Theobald 1903.

Systematic notes. Anopheles aconitus belongs to the rather homogeneous minimus-funestus series of the subgenus Myzomyia. The other members of this series are minimus (Oriental), varuna (India, Burma), flavirostris (Philippines and possibly the Malay Archipelago), funestus (Ethiopian), mangyanus (Philippines), fluviatilis (India, Indochina, southern China, Burma), and filipinae (Philippines). King (169) has done much to clarify the relationships of these species. The range of aconitus overlaps only with that of varuna, fluviatilis, minimus, and possibly flavirostris, and in the older literature there is considerable confusion of aconitus and minimus. In aconitus there is a fringe spot at the apex of vein 6 which is usually absent in varuna and minimus (including flavirostris), and the pale apical half of the proboscis in aconitus is dark in varuna and minimus. Anopheles fluviatilis is separable from these three species in that the subapical band of the palps is narrower than the intervening dark band as compared to the other species in which it is as broad or broader. The larva of aconitus differs from these species in having finely frayed anterior clypeal hairs and branched posterior clypeals.

Bionomics. In the Netherlands Indies the larvae of aconitus were collected in mountainous areas as well as in the plains. Most of the records are from rice fields and fresh-water ponds. They have never been found breeding in polluted or brackish water, or in artificial containers. In Burma aconitus larvae have been found in fresh-water pools with grassy edges, pools with much aquatic vegetation and shade, arms of lakes, pools in creek and river beds, and in drainage ditches. In Malaya, larvae were collected in clear, open water such as in swamps. The larvae first appear in rice fields when the crop is half grown and increase rapidly following the harvest.

Adults are commonly taken in houses and feed readily on man and livestock. In the Netherlands Indies it has been observed that aconitus has a definite preference for human blood. Raynal and Gaschen (242), however, obtained contradictory results. Flight ranges up to one-half mile have been observed in the Netherlands Indies.

Relation to disease. In the Netherlands Indies natural infections of 0.6 to 17.8 per cent have been reported for aconitus, with a mean infection rate of 1.7 per cent. However, these data must be discounted very heavily because of confusion in identification with minimus. Nevertheless, aconitus is regarded by Dutch malariologists (Overbeek and Stoker (234)) as a species of some importance in malaria transmission. In French Indochina naturally infected females have been found. Borel (42) stated that it is strongly suspected as a vector in South Annam, and Le Nestour (194) described it as one of the most dangerous in this area. Genevray et al (126) discussed an epidemic in Tonkin in which aconitus was undoubtedly the vector, and reported natural infection rates of 1.5 to 1.7 per cent at Cochinchina. Moreau (221) regarded aconitus as an important malaria vector in Cambodia, although Gaschen and Marneffe (122) considered it a vector of secondary importance. Naturally infected specimens have been recorded from Burma and Malaya as well, but in these regions it is regarded as of potential rather than actual importance in the transmission of malaria.

Brug (51) reported complete development of Wuchereria bancrofti larvae in aconitus on Kabaena near Celebes. Of 171 specimens, 2 per cent were found to be naturally infected.

Distribution. Anopheles aconitus is a strictly oriental species, ranging from India, Burma (and the Andaman Islands), Siam, Indochina and Hainan, throughout the Malay Peninsula and Archipelago including Celebes. It does not occur in the Philippines or Formosa, but may extend into southern China. Distribution records for Borneo and the Lesser Sunda are incomplete. The Philippine records of aconitus are generally referable to filipinae.

Sources of Distribution Records.

Burma: 67, 68.

China: 288.

India: 67, 68, U.S.N.M.

Indochina: 18, 42, 63, 119, 122, 126, 127, 128, 129, 194, 210, 211, 305, 313.

Malay Archipelago: 8, 51, 53, 205, 285, 328, 329, 334.

Malaya: 19, 132, 133, 184, U.S.N.M., J.H.

Siam: 19, 25, 30, 59, U.S.N.M.



ANOPHELES ANNULARIS

- Specimens examined
- Records from literature
- ▨ Probable range

Synonymy. A. fuliginosus Giles 1900; A. leucopus Dönitz 1901.

Systematic notes. Confusion of annularis with philippinensis and pallidus has occurred in early literature especially in Malaya. The wing vein 5 of annularis, however, is extensively dark or with at least a dark spot at the base of the fork in comparison with the extensively pale vein and fork of philippinensis and pallidus. In the larvae, the palmate hair of segment I is well developed in annularis and vestigial in the latter species.

Bionomics. Larvae of annularis were recorded from a variety of situations. It breeds principally in large fresh-water ponds containing aquatic vegetation, shallow vegetated margins of lakes and slowly-moving streams, and rice fields. Other breeding sites usually associated with clear water and aquatic vegetation were ditches, swamps, borrow pits, and large tanks.

According to Christophers (67) annularis is a strong flyer and may be found at considerable distances from its breeding places. It appears to be attracted to artificial light. The females are principally zoophilic in their feeding habits, although they attack man readily. Timbres (304), however, characterized the species as definitely anthropophilic at Bengal, India. Russell (253) collected resting adults along eroded overhanging stream banks during the day.

Relation to disease. Experimental infections of annularis with Plasmodium falciparum and P. malariae were reported, but little data for P. vivax is available. The status of this species as a vector of malaria is uncertain since early data may be confused with philippinensis, although it appears to be of importance only in hyperendemic areas. According to a compilation of data by Swellengrebel and Rodenwaldt (285), only two or 0.2 per cent of 932 specimens collected at Sumatra were naturally infected. All of 246 collected at Java were negative. Covell

(75) listed the results of various authors at Burma where natural infections ranged from 0.5 per cent to 1.5 per cent with a mean average of 0.83 per cent for a total of 1913 specimens. Borel (42) stated that annularis was of no importance in Cochinchina and Annam, and the report for Malaya of 4.3 per cent natural infections by Stanton (Simmons and Aitken (270)) is misleading in that only 23 specimens were studied. In Yunnan Province, China, Robertson (245) reported 1.57 per cent infections of 380 specimens dissected, and Chang (62) 1.5 per cent of 392 specimens. None were infected of 1,445 specimens dissected by Manalang (208) in the Philippine Islands. Feegrade (100) stated that annularis was the common vector of malaria on the plains of India. However, the extensive work of many Indian authors as compiled by Covell (75) and Simmons and Aitken (270) demonstrates that it is of little importance. The mean average for a total of 7,759 dissections was 0.14 per cent.

According to Neveu-Lemaire (228) and Prawirohardjo (240) the complete development of Wuchereria bancrofti was observed in annularis of the Netherlands Indies.

Distribution. An Oriental species, annularis ranges from India and Burma extending northward into China at Yunnan Province including Formosa and Hainan, and southward through Indochina, Siam, the Malay Peninsula, Sumatra and Java. One collection was listed for Borneo, and a record cited for Timor by Lee and Woodhill (190).

Sources of Distribution Records.

Burma: 67, 100.  
China: 61, 62, 106, 109, 245, 288, 343, 345.  
India: 67, U.S.N.M.  
Indochina: 18, 42, 97, 127, 128, 317, 318.  
Japanese Archipelago: 229, 232, 340.  
Malay Archipelago: 49, 53, 240, 285, 328.  
Malaya: 19, 25, 133, J.H.  
Philippine Islands: 144, 254, U.S.N.M.  
Siam: 19, 25, 30, 59, 278.



ANOPHELES (MYZOMYIA) CULICIFACIES Giles 1901

Systematic notes. In China, Siam, and Indochina, culicifacies probably would be confused only with fluviatilis. The adult females are separable in that the fringe spots, numerous in fluviatilis, occur at only one or two veins in culicifacies, and in the former species the pale area at the base of vein 1 is not interrupted by a dark spot as in culicifacies. In comparison with fluviatilis, the anterior tergal plates on segments II to VII of the larvae are very large in culicifacies involving the small median posterior plate.

Bionomics. The larvae of culicifacies have been collected from a variety of fresh-water situations such as irrigation ditches and seepages, slow-moving streams, pools in canal and river beds, and freshly formed collections of rain water. Other breeding sites listed were freshly dug borrow pits, fallow rice fields, shallow tanks and pits, and wells. Fresh, clean water is preferred although Christophers (67) reported breeding in brackish water. Russell and Rao (258) found no appreciable effect of sunlight or shade upon larval breeding, but reported that dense vegetation such as rice served as mechanical barriers and inhibited oviposition.

A flight range of from 1.5 to 1.75 miles in some instances into the wind was observed by Russell et al (256). Adults rest in houses, cowsheds, etc., during the day. Weyer (335) regarded culicifacies as zoophilic in its feeding preference. The females are known to feed readily on man, cattle, and birds.

Relation to disease. In India, Weyer (335) considered culicifacies the most important vector of malaria, and responsible for many epidemics

especially in Ceylon and Northwest India. In a compilation of data reported by Indian authors natural infection rates of 30 per cent at Ceylon and 21 per cent at Sind were listed with a mean average throughout India of 1.32 per cent for 13,470 dissections. According to Weyer, Ramsay and McDonald listed a total of 24,187 dissections of which 0.7 per cent were sporozoite and 2.1 per cent cyst infections. Covell (75) reported additional data ranging from 0.3 to 8.6 per cent with a mean average infection rate of 1.0 per cent for 4,262 specimens. In southeast India, Russell and Rao (257) found a sporozoite index of only 0.061 per cent of 36,414 dissections. They also demonstrated, however, that it was the principal vector in this highly endemic area. Gater (125) considered culicifacies one of the most important vectors in India, Burma, and Siam, and Feng (108) regarded it as the principal vector in the northwest plains of China. Robertson (245) reported 3.8 per cent natural infections of 52 specimens collected at Yunnan Province, China.

Distribution. Principally an Indian species, culicifacies ranges from Baluchistan to Burma including Ceylon, and was reported from South Arabia. Eastward it ranges through Siam and the Malay Peninsula as far south as the Malay States, into Tonkin, Indochina, and northward into Yunnan Province, China.

Sources of Distribution Records.

Burma: 67.  
China: 61, 62, 109, 118, 245, 343, 345.  
India: 67, U.S.N.M.  
Indochina: 118, 218, 219, 313.  
Malaya: 19.  
Siam: 19, 25, J.H.



**Synonymy.** *Nyssorhynchus annulipes* var. *moluccensis* Swellengrebel and Swellengrebel de Graaf (?); *Anopheles punctulatus* var. *moluccensis* Swellengrebel and Swellengrebel de Graaf 1920 (at least as applied in eastern Melanesia); *Anopheles punctulatus* Dönitz of authors.

**Systematic Notes.** The relation of *farauti* and *moluccensis* to *punctulatus* is perplexing and has been the source of considerable confusion. According to Knight and Farner (173), both *farauti* and *moluccensis* were originally described as forms with the proboscis entirely dark (except labellum), whereas *punctulatus* was described as a species in which the apical half of the proboscis was entirely pale. However, Dutch entomologists soon encountered, both in the Moluccas and New Guinea, intermediate forms in which there was a pale area on the ventral surface of the proboscis. Hence, *moluccensis*, in their conception (Swellengrebel and Rodenwaldt (285)), contained a form with a completely dark proboscis as well as one with a pale ventral patch. The latter type has also been found in eastern New Guinea and also a similar form in the Solomons. The Solomons form has been described as a separate species, *koliensis*, by Owen (235). In the New Hebrides all specimens collected have had entirely dark probosces. Because of these intermediate forms it is difficult at present to say whether or not the *farauti* of eastern Melanesia is the same as the *moluccensis* of the Moluccas and New Guinea. Extensive studies now in progress however should do much to clarify this relationship. Knight and Farner (173) have placed the subspecies *moluccensis* in synonymy with Laveran's species *farauti*, although Lee and Woodhill (190) have not accepted this change in nomenclature. Lee (189) suggested that *farauti* is an ecologic subspecies of *punctulatus* and that the intermediate forms merely represent a normal subspecific intergradation. In support of this contention is the fact that intermediate forms have never been found in the New Hebrides where only *farauti* occurs. On the other hand, in areas where *punctulatus* and *farauti* both occur, intermediate forms are occasionally encountered.

**Bionomics.** Perry (238) summarized the experience of Army and Navy entomologists in the Solomons-New Hebrides area with *farauti*. Dry season breeding places consisted primarily of rivers, streams, ponds, lagoons, taro gardens under water, improperly constructed roadside ditches, and occasionally wells and animal wallows located near plantations or native homes. During the wet season, breeding may occur in almost all types of natural and man-made catchments. Sites, which during the dry season are unsuitable to *farauti*, become favorable breeding localities during periods of heavy rains. On Guadalcanal it has been observed that there is a mechanical transportation of eggs, larvae, and pupae to the flat alluvial plains of the northeastern coast with flush-

ing of the aquatic stages from their permanent breeding places. Road-ruts, foxholes, bombcraters, slit trenches, and borrow pits have been found to be important breeding places throughout the area. Water may be clear, turbid, somewhat stagnant, brackish, or pure rain water and aquatic vegetation may or may not be present. Although open sun-lit water is preferred, larvae have been collected from pools in a heavily shaded mangrove situation. Only rarely have larvae been taken from coconut shells. It has been noted repeatedly that the appearance of *farauti* breeding is definitely associated with man-made clearings. The aquatic cycle requires from 13 to 15 days. These observations agree well with those given by Swellengrebel and Rodenwaldt (285) for *farauti* and *koliensis* (as *moluccensis*). These authors point out that the larvae are found primarily in water exposed to sun and that "moluccensis"-malaria is usually man-made. Breeding apparently was independent of the presence of aquatic vegetation, and water varying from clear streams to brackish pools was observed.

According to Perry (238), adults are most active at night, and are seldom found within native huts during the day. In the New Hebrides it was found that the females fed readily on horses and cattle as well as on man. Swellengrebel and Rodenwaldt (285) report only man as the host of *farauti* (as *moluccensis*).

**Relation to disease.** Throughout the Moluccas, New Guinea and adjacent islands, Admiralty Islands, Bismarck Archipelago, northern Australia, and the Solomon Islands, *farauti* is the important vector of malaria. In the New Hebrides it is the only vector. This is due not only to its high susceptibility to infection but also to its breeding habits which places it in close proximation to humans. Natural infection data in New Guinea for *farauti* (as *moluccensis*) summarized by Swellengrebel and Rodenwaldt (285) ranged from 4.9 to 12.7 per cent, with a mean infection of 8.69 per cent for 207 dissections.

In the Solomons-New Hebrides area *farauti* has been shown to be an important vector of filariasis. In the New Hebrides, Byrd and St. Amant (57) reported that 13.72 per cent of 1,239 specimens were infected with *Wuchereria bancrofti*, and at Guadalcanal 51.9 per cent of 655. Of these, many were demonstrated to carry infective larvae.

**Distribution.** The distribution of *farauti* is strictly Australasian, extending from the Moluccas to the New Hebrides and southward into northern Australia. It does not occur in New Caledonia.

#### Sources of Distribution Records.

Australia: 206, 244, 294, 297, 298, U.S.N.M.  
Melanesia: 9, 12, 31, 58, 92, 285, 294, U.S.N.M., J.H.



Synonymy. A. aconitus tonkinensis Toumanoff 1931.

Systematic notes. According to Christophers (67), the subspecies candidiensis is separable from the typical form in that the pale apex of the female palp is more extensive in candidiensis and the preceding pale band broader, with the dark intervening area much shorter (half or less than half the length of the apical pale area). In the larvae, the branches of the inner clypeal hairs are fewer in number and are stouter in the subspecies.

Bionomics. Christophers (67) gave running water in grassy drains as the typical breeding site for larvae. In China, Feng (109) reported larval breeding in grassy shallow water such as seepage water from hill-sides, abandoned rice fields, and amongst the stubble of rice fields in the foot hills. In addition, grassy margins of lakes and swampy land was given for the jeyporiensis of India.

The typical species has been commonly collected in houses and cattle sheds, and was reported to attack fiercely and feed readily on man (67). Feng (109) stated that in China the females of candidiensis bite man freely. Toumanoff (311, 321) indicated that the feeding habits of the females were not specific, but reported from 40 to 97 per cent of the blooded females examined positive for human blood. Raynal and Gaschen (242) found that about 85 per cent of 359 blooded specimens contained human blood.

Relation to disease. In South China and Indochina, candidiensis is considered the most important vector of malaria next to or equal with minimus. Jackson (159, 160) at Hong Kong Colony reported high natural infection rates ranging from 2.18 to 9.93 per cent. For a total of

15,601 dissections, an average of 8 per cent were found to be infected of which the greater part were both salivary and midgut infections. Robertson (245) reported 5.9 per cent infections of 101 specimens collected in Yunnan Province, and Yao (342) 0.2 per cent of 1,363 and Feng (108) 1.89 per cent of 53. At Amoy, Feng (108) reported one infection of 28 specimens, and from Kwangsi Province two (4 per cent) of 56. Toumanoff (307, 313) found an infection rate of 0.72 per cent of 826 specimens for Tonkin, but negative results for 424 specimens collected in Annam. For a total of 3,419 specimens from North Indochina, Gaschen and Marneffe (122) reported that 0.99 per cent were infected.

At Hong Kong Colony, candidiensis appears to be an important vector of Wuchereria bancrofti. Jackson (161) reported natural infections ranging from 0 - 4.6 per cent. In Indochina, Toumanoff et al (321) also reported natural infections with filaria.

Distribution. A relatively restricted Oriental species, candidiensis ranges from India, Burma, and Tonkin, Indochina southward to about 18°N. latitude including Hainan, and northward into China to about 28°N. latitude including Formosa. In eastern India and possibly Burma and Tonkin, the distribution records may be confused to some extent with the typical species.

Sources of Distribution Records.

Burma: 67.

China: 61, 62, 104, 106, 108, 109, 159, 161, 162, 195, 200, 204, 243, 245, 288, 313, 337, 338, 342, 343, 345, U.S.N.M.

India: 67.

Indochina: 18, 118, 120, 126, 127, 128, 191, 192, 211, 218, 219, 305, 313, 318, 321.

Japanese Archipelago: 224, 229, 232.



Systematic notes. The adults of Anopheles kochi are distinctive and readily recognized. The presence of prominent black scale tufts apically on ventral segments II to VII should immediately distinguish this species. The larvae closely resemble A. punctulatus and A. tessellatus. It is separable from punctulatus by the inner prothoracic hair which lacks a tubercle in kochi. In kochi the palmate leaflets of abdominal tergite IV are more serrate and sharply pointed than tessellatus, and the inner prothoracic hairs have from 4 to 10 branches as compared to the usual three-branched hairs in tessellatus.

Bionomics. The larvae of kochi were collected from a variety of habitats. They appear to favor turbid water, although fresh water situations have also been encountered. Larvae were frequently found in small muddy pools during the rainy season, follow rice fields, flowing irrigation ditches, stagnant drains, jungle pools with decaying vegetation, buffalo holes, and such temporary water collections as hoof marks, road ruts and depressions in the vicinity of habitations. Relatively small, open situations were preferred, which were shaded or exposed to sunlight. Larvae were never encountered in salt or brackish water. In the Philippines, breeding was commonly encountered in cut bamboo and artificial containers.

Anopheles kochi is a moderately domestic mosquito, and appears to prefer houses and stables as a resting place. In the Philippines, adults were also collected under the overhanging banks of streams and found resting on shaded stone walls. At Assam, India, however, adults were frequently encountered in the jungle. The females of kochi will feed readily upon man but appear to have no distinct preference for human blood, and in areas where cattle are present in large numbers they are predominately zoophilic. Gater (125) reported that in Malaya, kochi bites man with reluctance and not more than 48 per cent of the females starved in captivity fed upon human blood.

Relation to disease. Successful experimental infections of kochi have been frequently demonstrated, and Green and Gater (132) reported 90 per cent midgut and 59 per cent salivary gland infections with Plasmodium falciparum and 80 per cent midgut and 100 per cent salivary gland infections with P. vivax. This species appears to be an excellent vec-

tor of malaria, although it is primarily zoophilic and apparently of importance only when occurring in large numbers. In the Netherlands Indies, especially in Sumatra where the species is abundant, kochi is considered an important vector. Green and Gater (132) and Swellengrebel and Rodenwaldt (285) summarized malarial investigations in this area. Natural infection rates ranged from 0.4 per cent to 11.5 per cent. Of 5,610 dissections reported by 16 investigators, an average of 1.01 per cent were found to be naturally infected. Weyer (335) considered kochi of no importance in India, although Ramsay (241) reported 0.1 per cent natural infections of 2,094 specimens collected at Assam. Toumanoff (308, 313) considered the species of little importance at Tonkin, Indochina, and Gater (125) found no natural infections in Malaya. In the Philippines, Simmons and Aitken (270) concluded that kochi is of little importance as a vector of malaria.

Distribution. Anopheles kochi is a widely distributed Oriental species, extending into the Australasian Region at the Moluccas. It ranges from Bengal, India, in the west to about 28° N. latitude in South China, extending southward through Burma, Siam, Indochina and the Malayan Peninsula and throughout the Malay Archipelago to the Lesser Sunda Islands but exclusive of Timor. Its range includes the Philippines, Borneo, and the Celebes, extending into the Australasian Region in the Moluccan Islands of Halmahera, Soela, Boeroe and Ceram. Isolated collection records for the Aroe Islands and Formosa were recorded in the literature, but these are doubtful.

Sources of Distribution Records.

Burma: 67.  
China: 54, 61, 106, 108, 109, 195, 200, 245, 288, 336, 343, 345.  
India: 67, U.S.N.M.  
Indochina: 97, 118, 127, 128, 318.  
Japanese Archipelago: 224, 340.  
Malay Archipelago: 49, 53, 131, 165, 226, 263, 280, 285, 328, 329, 334, J.H.  
Malaya: 132, 133, 143, J.H.  
Melanesia: 285.  
Philippine Islands: 144, 254.  
Siam: 25, 59, J.H.



ANOPHELES MACULATUS

- Specimens examined
- Records from literature
- ▨ Probable range

Synonymy. A. hanabusai Yamada 1925.

Systematic notes. A. maculatus is a highly ornamented and readily recognized species. It is similar to karwari, although the speckled legs of maculatus will distinguish it. In the larvae, the tips of the abdominal palmate hairs of maculatus are readily broken off, resembling in this condition the blunt hairs of karwari.

Bionomics. A. maculatus is generally associated with hilly or mountainous country, and according to Swellengrebel and Rodenwaldt (285) breeds principally in mountain streams especially in the Netherlands Indies. In Malaya, larvae were collected principally from drains, and to a lesser degree from pools and streams. Larvae were also encountered in seepages, springs, rice fields, marshes, borrow pits, lake margins, wells, and reservoirs. Fresh water is generally preferred, although larvae may become adapted to stagnant and polluted water. They were never found in salt or brackish water. Sunlit or lightly shaded situations were most generally encountered, and collections in dense jungle were very rare. Recently cleared jungle areas may become serious breeding sites for this species. Aquatic vegetation was not associated with ideal breeding conditions, although in the Philippines Russell and Baisas (255) found larvae most frequently in algae at the edges of shaded forest streams.

Adults were seldom collected in buildings, and apparently rest during the day in vegetation. In Java, Venhuis (327) collected 136 females in resting places along the banks of a stream of which three were naturally infected with malaria. According to Christophers (67), females will enter houses readily and are attracted by artificial light. They feed readily on human blood, but may be deflected from man where cattle are abundant.

Relation to disease. Females of this species have been readily infected with malaria by artificial means. Green and Gater (132) working in Malaya demonstrated 70 per cent midgut and 59 per cent salivary gland infections with Plasmodium falciparum, and 80 per cent midgut and 20 per cent salivary gland infections with P. vivax. In Malaya and certain areas of the Netherlands Indies, maculatus is regarded as one of the most important vectors of malaria. It was the only naturally infected species found by Scharff (264) at Penang and Dindings. According to Covell (75), an average infection rate of 10.7 per cent of 75 specimens dissected were reported by four workers in the Malaya area. In east Java, Venhuis (327) reported one (0.14 per cent) sporozoite infection of 698 specimens collected in houses and stables, and two sporozoite and

one oocyst infections of 133 specimens (2.3 per cent) collected along the banks of a stream. Walch and Soesilo (332) in Java reported four natural infections (2.96 per cent) of 135 dissected. Investigations in the Sumatra area were summarized by Swellengrebel and Rodenwaldt (285). At Sumatra, Doorenbos reported that 12 or 2.83 per cent of 424 specimens were infected, although a total of 92 examined by three other workers were negative. On adjacent islands, Essed found three or 15.0 per cent of 20 specimens positive at Riouw, and Bloch five or 1.35 per cent of 369 specimens collected at Banka.

Venhuis (327) considered maculatus of minor importance as a vector of malaria in Indochina, South China, and British India, and Toumanoff (313) stated that it was primarily zoophilic in Indochina and South China (Hongkong). However, Borel (42), LeFebvre (192), Moreau (221), Le Nestour (194), and Andre and Toumanoff (18) considered it to be an important vector in Indochina. Toumanoff (306, 307) reported infection rates at Tonkin of 3.2 per cent and 2.22 per cent. Investigations by others in this same area range from 1.4 per cent to 4.44 per cent. At Hongkong, Jackson (159, 160) in a series of 230 dissections reported eight or 3.48 per cent infections, although all were negative in four other series with a total of 848 specimens. Toumanoff reported an infection rate of 3.5 per cent with 230 specimens. In Yunnan Province, Chang (62) found 3.0 per cent infections with 132 specimens, and Robertson (245) 7.1 per cent with 42 specimens. At Assam, India, Wever (335) reported only six positives (0.3 per cent) of 1919 specimens collected, and Ramsay (241) negative results with 3,374 dissections.

Distribution. A. maculatus is confined to, but widely distributed throughout, the Oriental Region. It ranges from India and Burma into South China below about 30° N. latitude, including Formosa and the Hainan Islands, southward throughout Siam, Indochina, the Malay Peninsula and the Sunda Islands to Timor, including Borneo, Celebes and the Philippines. Lee and Woodhill (190) list a very doubtful collection from Aroe.

Sources of Distribution Records.

Burma: 67.

China: 54, 61, 62, 69, 104, 106, 108, 109, 159, 160, 162, 195, 200, 204, 245, 288, 313, 336, 338, 343, 345, U.S.N.M., J.H.

India: 67, U.S.N.M.

Indochina: 18, 42, 118, 119, 192, 194, 313, 317, 318, J.H.

Japanese Archipelago: 229, 231, 232, 340.

Malay Archipelago: 3, 51, 53, 131, 279, 285, 330, 334.

Malaya: 132, 133, 264, U.S.N.M., J.H.

Philippine Islands: 144, 254, U.S.N.M.

Siam: 25, 30.



ANOPHELES MINIMUS

- Specimens examined
- Records from literature
- ▨ Probable range

ANOPHELES (MYZOMYIA) MINIMUS Theobald, 1901,  
(including minimus var. flavirostris Ludlow 1914).

Synonymy. Anopheles formosaensis Tsuzuky 1902; Myzomyia flavirostris Ludlow 1914.

Systematic notes. Anopheles minimus has frequently been confused with other species of the homogenous funestus-minimus series. In the Pacific area, the distribution of minimus overlaps that of aconitus, fluviatilis and probably minimus flavirostris in the Malay Archipelago. Anopheles fluviatilis may be separated from minimus (including flavirostris) and aconitus by the subapical pale band of the palp which in fluviatilis is narrower than the intervening dark band. In aconitus there is a fringe spot at the apex of vein 6, which is absent in minimus and its variety flavirostris. In the larvae, aconitus is distinct in that the anterior clypeal hairs are finely frayed, and the posterior clypeals are branched. Fluviatilis, minimus, and flavirostris are indistinguishable in the larval stage.

King (169) has shown that the minimus of the Philippine Archipelago is sufficiently distinct from the typical form as described from China to justify its separation as a subspecies flavirostris. They are distinguishable by the pale scaling of the ventral and lateral aspects of the proboscis in flavirostris, and the inner claspette hair of the male hypopygium which is long in flavirostris and variably short or absent in typical minimus. Outside of the Philippines, the status of flavirostris is uncertain. Venhuis (329) reported collections in the eastern part of Java, and a doubtful collection in Timor was discussed by Lee and Woodhill (190). Gater (125) regarded the status of flavirostris in Malaya as uncertain, and Christophers (67) was doubtful as to the position of the Indian form. In the Philippines, flavirostris is closely associated with mangyanus Banks and filipinae Manalang. It is separable from these two species by its distinctive pale scaled proboscis. In the larval stage, the anterior clypeal hairs of filipinae are frayed and the posterior hairs branched, while those of flavirostris are all simple. The thoracic palmate hairs of mangyanus terminate in a filament while those of flavirostris are relatively blunt.

Bionomics. Anopheles minimus breeds typically at the edges of clear slow-running partly shaded streams and springs. The larvae are not found in dense jungle, although it may breed freely in streams covered with secondary growth following clearing of the jungle. It is reported from slow-running streams and springs with grassy margins, at the edges of swamps, in irrigation channels, drains, rice fields and borrow pits usually in clear water. The breeding habits of flavirostris are similar to those of the typical species. In the Philippines, the larvae are most prevalent in foothill streams along bamboo shaded margins. Russell (254) states that larvae are never found in rice fields or brackish water. Minimus occurs abundantly at low altitudes but is also common at altitudes of 2,000 to 3,000 feet, while flavirostris in the Philippines occurs throughout the foothills and rolling land not over 2,000 feet in altitude.

The adults of minimus are found abundantly in houses and cattle sheds. They feed readily upon man and in South China and Indochina are reported to be the most anthropophilic of anopheline species. Simmons and Aitken (270) in the Philippines found that the overhanging banks of streams is the normal resting place for flavirostris adults, and that they are seldom found within houses. Russell and Santiago (261) stained adults of flavirostris and report the normal flight range to be at least 546 yds., and over a mile when aided by strong winds.

Relation to disease. Anopheles minimus is considered to be an important vector of malaria wherever it occurs. In China, along with je-

poriensis, it is the most important vector in the hilly regions of China south of 30° N. latitude. At Amoy, Fukien Province, Feng (103) reported a sporozoite infection rate of 8.57 per cent and an oocyst infection rate of 29.85 per cent. At Hongkong, minimus was considered the most anthropophilic of the anopheline species, and Jackson (159, 160) and Toumanoff (310, 313) reported natural infection rates of from 3.6 per cent to 12.5 per cent. In Yunnan Province, Chang (62) and Robertson (245) reported 9.8 per cent infections with dissections of 340 and 316 specimens respectively, and Yao and Ling (343) an infection rate of 3.3 per cent with 5,883 dissections. Crook (76) reported an infection rate of 12.4 per cent of 8,802 specimens collected in Szechwan Province. Toumanoff (313) considered minimus to be the most anthropophilic of anopheline species in Indochina, with 93 - 97 per cent of all blooded females examined positive for human blood. He also reported natural infection rates of 4.37 per cent at South Indochina to 5.56 per cent at Tonkin (Toumanoff, et al (321)). Lefebvre (193) found from 5.4 per cent to 9 per cent natural infections at Laos. In Cochinchina, Mesnard and Morin (215) reported 6.62 to 7.62 per cent natural infections. Genevray et al (127) reported 10.5 per cent infections, and Gaschen and Marneffe (122) 3.91 per cent infections. Weyer (335) considered minimus among the most important vectors in Siam and Formosa. Natural infection rates for India range from 2.2 per cent (Ramsay (241)) to 6 per cent in North Bengal and 10 per cent in Assam (Weyer (335)). In the Malay Archipelago, minimus is also considered an important vector.

In the Philippines, flavirostris is considered the most important vector of malaria. However, King (169) has suggested that mangyanus and filipinae be further investigated before the exact status of flavirostris, with which these species have been frequently confused, can be definitely ascertained. In Java, Overbeek and Stoker (234) reported 1.3 per cent natural infections for flavirostris, and Venhuis (329) 1.01 per cent.

Jackson (161) at Hongkong reported natural infections of minimus with Wuchereria bancrofti, and Toumanoff et al (321) observed proboscis infections and considered minimus as the probable vector of filariasis in Tonkin.

Distribution. Anopheles minimus is strictly an Oriental species. Its range extends from eastern India, Ceylon and Burma in the west, to about 30° N. latitude in China including Formosa in the north, and extending southward through Indochina, Siam, the Malay Peninsula and Archipelago westward to the Lesser Sunda Islands and Celebes. There are no records from Borneo, and data from the Ryukyu Islands is doubtful.

Anopheles minimus flavirostris is principally confined to the Philippine Islands, although specimens have been collected from three localities in East Java, and a doubtful collection was recorded from Timor.

#### Sources of Distribution Records.

Burma: 67, 68.  
China: 61, 62, 69, 76, 104, 106, 108, 109, 159, 161, 162, 195, 200, 204, 243, 245, 288, 313, 336, 337, 338, 342, 343, 345, U.S.N.M., J.H.  
India: 67, 68, U.S.N.M.  
Indochina: 18, 20, 97, 118, 120, 127, 128, 191, 192, 194, 278, 313, 319, 321.  
Japanese Archipelago: 229, 231, 232, 340, U.S.N.M.  
Malay Archipelago: 3, 51, 53, 205, 285, 328, 329.  
Malaya: U.S.N.M.  
Philippine Islands: 144, 254, U.S.N.M.  
Siam: 19, 25, 59.



ANOPHELES (MYZOMYIA) PHILIPPINENSIS Ludlow, 1902

Synonymy. Anopheles fuliginosus philippinensis Ludlow of Swellengrebel and Rodenwaldt (285).

Systematic notes. Anopheles philippinensis is very similar to A. annularis and has been frequently confused with this species. The adults are distinguished by coloration of the fork of vein 5 which is dark in annularis and light in philippinensis. In the larva, the prothoracic hairs are pigmented and their bases confluent in annularis, while in philippinensis the hairs are unpigmented and separable at the base.

Bionomics. A. philippinensis is usually associated with abundant vegetation, and favors large bodies of water such as sloughs, quiescent shaded margins of lakes, impounded water with aquatic vegetation, large ponds, and open rush swamps. Larvae were also collected from recently planted rice fields, stagnated canals and ditches with abundant vegetation, and borrow pits. In India, Christophers (67) reported larval breeding in tanks covered with aquatic vegetation, seepage water, and along the grassy margins of a slow-running stream.

Covell (75) in Burma collected adults of philippinensis in houses, cattle sheds and stables. Manalang (209) observed that adults are strongly attracted to white light.

Relation to disease. This species is considered of some importance as a vector of malaria in certain hyperendemic areas of India. Sur (283), and Sur and Sur (284) with 1081 dissections found natural infection rates ranging from 4.5 per cent to 2 per cent at Bengal. Weyer (335), however, stated that with a total 36,194 dissections by several workers in the Bengal area, only 179 sporozoite infections have been demonstrated. In Burma, three of 487 specimens (0.6 per

cent) were shown to be naturally infected (Covell (75)). Weyer (335) listed for Assam an infection rate of 0.29 per cent with 689 dissections, although a total of 6,895 dissections were all negative for Ramsay (241). While Timbres (304) stated that philippinensis was definitely anthropophilic at Bengal, India, Toumanoff (309) was of the opinion that it was predominately zoophilic in Indochina and reported negative dissection rates. Gater gave only negative results with 562 dissections of specimens collected in Malaya, and Manalang (207) with 3,657 dissections in the Philippines.

Neveu-Lemaire (228) reported the complete development of Wuchereria bancrofti in this species. Only a few specimens, however, were found to be naturally infected.

Distribution. A. philippinensis is confined to the Oriental region ranging from Bengal, India, eastward throughout Burma and Assam, Indochina, and extending into South China at Yunnan Province and Hainan Island. Southward, philippinensis extends through Siam, the Malay Peninsula, Sumatra, and into Western Java. Numerous collections were recorded from the Philippine Archipelago. According to Lee and Woodhill (190), a collection recorded from Merauke, New Guinea, is referable to meraukensis and not philippinensis.

Sources of Distribution Records.

Burma: 67.  
China: 61, 109, 200, 288, 343, 345.  
India: 67, U.S.N.M.  
Indochina: 97, 127, 128, 313.  
Malay Archipelago: 53, 285.  
Malaya: 132, 143, U.S.N.M.  
Philippine Islands: 144, 254, U.S.N.M.  
Siam: 19, 30, J. H.



ANOPHELES (MYZOMYIA) PUNCTULATUS Dönitz, 1901

Synonymy. Anopheles punctulatus typicus Dönitz (of Swellengrebel and Rodenwaldt (285)).

Systematic notes. The relation of punctulatus to moluccensis and farauti has been discussed in the section concerning farauti. There seems to be a general agreement that punctulatus includes only those forms with the apical half of the proboscis pale. The larvae of punctulatus is separable from farauti mainly on the appearance of the inner and middle prothoracic hairs which in punctulatus arise from small weakly pigmented tubercles that are not enlarged or joined to form a single chitinous plate as in farauti. The adults are frequently confused with annulipes. In punctulatus vein 1 has 9 - 17 black spots (compared to 5 - 10 in annulipes), and the white apical portion of the female palpal segment III is usually divided by a black ring.

Bionomics. Swellengrebel and Rodenwaldt (285) report that the larvae of punctulatus were found in all types of water exposed to sunlight (except such artificial containers as cans and coconut husks) including pools, ditches, hoofprints, water barrels and even in the bilge water of boats. Although frequently found in clear water the larvae are not restricted to it, having been found in muddy pools and in pools with algae, but never in brackish water. Wheel ruts, trenches, and bomb-craters are favorite habitats. In general it is more characteristically a species of the inland and higher elevation although it does occur coastally. On Guadalcanal punctulatus has been found to be restricted to the valleys of the larger streams and rivers and occurs some distance from the coast as contrasted to farauti which is primarily a coastal form. Breeding places of punctulatus in Guadalcanal consist largely of temporary pools exposed to sunlight and rarely margins of streams, sloughs, and drying stream beds. During the rainy season its range is frequently extended to the coast at the outlets of rivers.

Adult females enter houses freely, and feed readily on man. The feeding and resting habits however are variable, and little is known concerning its blood preferences.

Relation to disease. Anopheles punctulatus, as a vector of malaria in the Australasian region, is second in importance to or equal with farauti. Natural infection rates as high as 11 per cent have been recorded (190). Swellengrebel and Rodenwaldt (285) listed natural infection rates of 2.68 per cent of 448 specimens in New Guinea (deRook), and one (6.25 per cent) of 16 specimens in Ceram (Mahulete). From Guadalcanal. Reports show 1.78 per cent infections of 112 specimens dissected.

Backhouse (21) working in New Britain, demonstrated complete development of Wuchereria bancrofti in punctulatus, and from Guadalcanal 15 per cent natural infections of 200 specimens were reported. Byrd and St. Amant (57) however reported only negative results for 64 dissections.

Distribution. Anopheles punctulatus is known to occur from the Moluccas eastward to the Solomon Islands. There are no reliable reports as yet of this species occurring in Australia, New Caledonia, or the New Hebrides. (The Australian record is questionable.)

Sources of Distribution Records.

Australia: 206, 294.

Melanesia: 9, 12, 32, 136, 206, 285, 294, 296, 298, 334, U.S.N.M.



Synonymy. *Anopheles rossi* Giles 1904.

**Systematic notes.** *Anopheles subpictus*, *A. vagus* and their subspecies constitute the non-spotted-legged series of the *Pseudomyzomyia* group of the subgenus *Myzomyia*. It is distinguishable in the adult female from *vagus* by the palpal banding. In *subpictus* the apical pale band of segment IV is the same length or not more than twice as long as the preceding dark band, while in *vagus* it is much broader. In the larvae, the close proximity of the outer and posterior clypeal hairs to the inner clypeals in *vagus* distinguishes the larvae of these species. The larva of *subpictus* is very similar to that of *sundaicus*, and differentiation can be made with certainty only by rearing (adult *sundaicus* has spotted femora while *subpictus* has non-spotted femora). Adult specimens of *sundaicus* which have had their femora rubbed are difficult to distinguish from *subpictus*.

*Anopheles subpictus* is obviously divisible into several races. These are treated best by King (168) and Toumanoff (313), although lack of adequate material from its entire range tends to obscure sub-specific relationships and distributions at the present time. Three subspecies are in current recognition: *subpictus subpictus* Grassi 1897 (Ceylon, India, Burma), *subpictus indefinitus* Ludlow 1909 (Philippine Islands, Formosa, Hainan), and *subpictus malayensis* Hacker 1921 (Malay Peninsula). Toumanoff's (313) description of the *subpictus* of French Indochina indicates that it may be close to *indefinitus* although it may be more similar to *malayensis*. Specimens from Java in the U. S. National Museum were placed tentatively in *indefinitus* although they may also be closer to *malayensis*. Material examined from New Guinea apparently belongs to an undescribed subspecies, agreeing with the observations of Christophers (67). A careful systematic revision of this species may more closely correlate its role in disease transmission.

**Bionomics.** The larvae of *subpictus* breed in widely varied situations including fresh or brackish and clear or polluted water. In brackish water *subpictus* is frequently found in association with *sundaicus* although it can withstand greater salt concentrations than this species. Furthermore, it does not appear to be as dependent upon the presence of blue-green algae as are the larvae of *sundaicus*. Christophers (67) included as larval habitats borrow pits, buffalo wallows, brick pits, drains, pools from leaks in irrigation ditches, furrows in gardens and fields, roof gutters, rice fields, and irrigation channels. In the Netherlands Indies, the larvae were found characteristically in small temporary accumulations of water as well as in brackish water, lagoons, and fish ponds with salt concentration as high as 8.5 gm. per liter. In the Philippines *subpictus indefinitus* is taken from both fresh and brackish water according to King (168), although it has not been noted to tolerate more than 2.5 gm. NaCl per liter. In French Indochina, Toumanoff (313) reported *subpictus* larvae from brackish water but gave no fresh-water records. Gater (124) stated that the most common breeding places in Malaya were pools and ponds, and that larvae occurred in open swamps but were rare in rice fields. In Malaya the larvae were also found in brackish as well as fresh water. *Anopheles subpictus* is primarily a coastal and lowland species.

In India *subpictus* is known as a domestic mosquito and is encountered frequently in dwellings and in stables. This observation appears to hold true throughout its range. Apparently its feeding habits are both zoophilic and anthropophilic. Data from the Philippines are meager although it (*subpictus indefinitus*) has been found in dwellings (Russell (253)). In French Indochina Raynal and Gaschen (242) found about 2 percent of the females with human blood and the remainder with blood of livestock or other mammals.

**Relation to Disease.** In general *subpictus* is unimportant in the transmission of malaria. Natural infections are rare, although experimentally this species has developed infections with *Plasmodium falciparum*, *malariae*, and *vivax* to the oocyst stage and to the sporozoite stage with *falciparum* and *vivax*. Christophers (67) and Covell (75) both stated that no natural infections with malaria plasmodia have been recorded in India. However, more recently Russell et al (259) found a natural infection rate of 0.05 per cent in southeastern India. In the Netherlands Indies (Java, Sumatra, Celebes), according to Swellengrebel and Rodenwaldt (285), the index of natural infection was low, ranging from 0.3 - 0.7 per cent (records exceeding this range were probably confused with *Anopheles vagus*). These authors are of the opinion that *subpictus* may become infected during epidemics in which *sundaicus* is the chief vector. In such cases, *subpictus* is noted to become involved late in the course of the epidemic. In the Netherlands Indies, it has been difficult to ascertain the role of *subpictus* in malaria transmission because of its close association with *sundaicus*. However, in areas on the west and south coasts of Celebes where *sundaicus* does not occur, *subpictus* is regarded by Swellengrebel and Rodenwaldt (285) as the vector of malaria. Also it has been regarded as of some importance in northern Madoera. Apparently its occurrence in large numbers in these regions compensates for the low rate of natural infection reported. Farinaud (96) reported one infected adult in 50 examined on Poulo Condore off the coast of southern Indochina. There are no reliable records of natural infections in the Philippines or in Malaya.

The relation of *subpictus* to the transmission of filariasis is also obscure. It has been reported as a possible vector in India, and Prawirohardjo (240) on the basis of experiments with artificial infections concluded that both *sundaicus* and *subpictus* were good vectors of *Wuchereria bancrofti* at Batavia, Java.

**Distribution.** *Anopheles subpictus* occurs westward throughout India and Burma and northward to the Himalaya Mountains. The northward continental limit in China and French Indochina is difficult to place at the present time because of the confusion with *vagus* and because of the lack of information and collection available from the interior. It extends into China only at the extreme southwest border of Yunnan Province, and probably occurs along the east coast to Hongkong including Formosa and Hainan. From Siam and Indochina, *subpictus* ranges southward throughout the Malay Peninsula and the Sunda Islands to Timor including Celebes, Moluccas, Boeroe, Ceram and the Philippines. Records for Borneo and New Guinea are incomplete. A questionable record for New Britain was given by Lee and Woodhill (190).

The distribution of the subspecies of *Anopheles subpictus* is poorly understood. Apparently *subpictus subpictus* extends no further west than Burma, *subpictus malayensis* has been reported from Malaya and Siam, and *subpictus indefinitus* occurs in the Philippine Islands, Formosa and probably Hainan. The *subpictus* of Java is probably *indefinitus* also. At present it cannot be stated with certainty which subspecies occur in Indochina, China, Sumatra, Borneo, Celebes, Lesser Sunda Islands, and New Guinea.

#### Sources of Distribution Records.

Burma: 67.  
China: 54, 108, 109, 195, 288, 336, 345.  
India: 67.  
Indochina: 42, 96, 194, 210, 211, 278, 313.  
Japanese Archipelago: 224.  
Malay Archipelago: 49, 53, 205, 226, 240, 285, U.S.N.M.  
Malaya: 19, 25, 133, J.H.  
Melanesia: 138, 190, 285, 294, U.S.N.M.  
Philippine Islands: 144, 254, U.S.N.M.  
Siam: 19, 25, 30, 59, J.H.



ANOPHELES (MYZOMYIA) SUNDAICUS Rodenwaldt, 1926

Synonymy. Myzomyia ludlowii var. sundaica Rodenwaldt, 1926; Anopheles ludlowii var. sundaica, Anopheles ludlowii and Myzomyia ludlowii of many authors.

Systematic notes. Anopheles sunaicus, Anopheles litoralis King (Philippines, possibly French Indochina coast), and Anopheles ludlowii (Theobald) (Philippines, Formosa, Moluccas, possibly Hainan) belong to the spotted-legged series of Pseudomyzomyia group of the subgenus Myzomyia. King (168) has studied this group and has described well the differences among the spotted-legged forms. In ludlowii about one-third of vein 5.1 is dark, in sundaicus it is half dark, while litoralis is intermediate. In ludlowii the fossa of the mesonotum has one or two broad scales, while there are 6-10 in litoralis and 2-6 in sundaicus. On vein 1 below the median costal spot in ludlowii there are usually three spots. In litoralis there are two, and usually two but sometimes one in sundaicus. The petiole of the anterior forked cell is markedly shorter than the cell itself in sundaicus, but not so in the other species. The fringe-spot between 5.2 and 6 is always absent in sundaicus but sometimes present in litoralis and ludlowii. At present it is not possible, with absolute certainty, to separate the larvae of subpictus Grassi from those of sundaicus. Both are found in brackish water and frequently occur together.

Bionomics. Except in Sumatra and in rare instances in Java, Anopheles sunaicus is known to breed only in brackish water. As yet no satisfactory morphologic differences have been demonstrated between the fresh-water and brackish-water forms. The former is apparently restricted to Sumatra. Larvae are found in coastal lagoons, coastal swamps, salt-water fish ponds, etc. It is generally associated with an abundant growth of green algae such as Enteromorpha. The optimum salt concentration is 12 to 18 grams NaCl per liter although it apparently will tolerate concentrations as high as 30 grams per liter. This species does not breed in virgin mangrove areas which are apparently ecologically unfavorable to it.

Anopheles sunaicus is a strong flier, and Overbeek and Stoker (234) have reported adults two miles from its breeding places. Adult females are commonly found in houses and cattle sheds, and it appears to be equally anthropophilic and zoophilic.

Relation to Disease. Throughout its range Anopheles sunaicus is a malaria vector of great importance. Weyer (335) cited examples of experimental infection indicating an unusual degree of susceptibility ranging from 86.9-100 per cent for Plasmodium falciparum, 80 per cent for P. vivax and 20-25 per cent for P. malariae. It is responsible for the extensive coastal endemic areas in the Malay Peninsula and Archipelago. In the Netherlands Indies, particularly Java, Sumatra, and the

Lesser Sunda Islands, it is repeatedly associated with severe epidemics. Natural infection rates as high as 54 per cent have been observed in some of these epidemics (9). Swellengrebel and Rodenwaldt (285) summarized data relative to the Netherlands Indies. In Sumatra, natural infection rates ranged from 2.21 to 15.2 per cent with a mean of 5 per cent for a total of 9,043 dissections. In Java, the rates ranged from 1.39 to 35.59 per cent with a mean of 2.99 per cent for 12,484 specimens. Kuipers and Stoker (181) reported an infection rate of 46.6 per cent during a malaria epidemic on the north coast of Sumatra. Its importance as a vector in Malaya was mentioned by Gater (124, 125) and in Siam by Roubaud and Treillard (252). On the southern coast of Indochina Farinaud (96) demonstrated a natural infection of 4.4 per cent for 223 specimens. At Bengal, India, Iyengar (157) reported an infection rate of 23.4 per cent for 836 dissections of which 20.3 per cent were sporozoite and 8.5 per cent oocyst infections.

Neveu-Lemaire (228) cited the observations of Rao concerning the complete development of Wuchereria bancrofti in sundaicus. Of nine experimentally infected females, Prawirohardjo (240) demonstrated in three specimens the development of infective bancrofti larvae. Natural infections have been reported (228, 325).

Distribution. Anopheles sunaicus occurs throughout the coastal areas of southeastern Asia, and is common along the coast in Java and throughout the Lesser Sunda Islands. In Sumatra the brackish water form is restricted largely to the western and northeastern coasts; its absence from the eastern coast being associated with the occurrence of virgin mangrove forest. The fresh-water form has an extensive distribution in central Sumatra in the Toba Lake area and elsewhere. In Borneo sundaicus is uncommon, due again to the presence of mangrove forests. Its distribution in Borneo is imperfectly known. It certainly occurs as far north as Mizi in Sarawak. In Celebes it seems to be confined to the southwestern peninsula although it has been reported to be expanding northward. Westward it has been reported as far as Calcutta. It also occurs on the Andaman Islands although positive reports from the Nicobar Islands are lacking. On the east coast of Asia its northward limit seems to be in the vicinity of Saigon. According to Treillard (324), northward along the French Indochina coast sundaicus is replaced by litoralis, this being associated with the decrease in coastal malaria. The occurrence of litoralis along the coast of the Asiatic mainland needs verification.

Sources of Distribution Records.

Burma: 67.  
India: 67.  
Indochina: 96, 252, 313, 324.  
Malay Archipelago: 8, 9, 53, 226, 234, 240, 263, 280, 285, 334, U.S.N.M.  
Malaya: 133, 264, U.S.N.M., J.H.



ANOPHELES (MYZOMYIA) TESSELLATUS Theobald, 1901

Synonymy. A. formosae Hatori 1901; A. deceptor Dönitz 1902; Myzomyia thortonii Ludlow 1904.

Systematic notes. At the eastern extremity of the Oriental Region, especially in the Moluccas, tessellatus has been frequently confused with punctulatus. Tessellatus may be readily distinguished by its halteres which are entirely covered with creamy white scales, and by its scutum on which scales are present only on the anterior margin. In the larvae, the inner prothoracic hairs of tessellatus are without a tubercle as compared to punctulatus, and the palmate hairs of abdominal tergite IV are not or hardly serrate and more blunt than in kochi.

Bionomics. In the Philippines, tessellatus was found breeding most abundantly in rice field pools, and to a lesser degree along the vegetated margins of streams and pools of spring water, and in irrigation ditches. Gater (125) in Malaya found that pools were the preferred breeding site with drains and swamp to a lesser degree, listing only one collection each from rice fields and streams. In the Philippines, tessellatus appears to prefer clear water although breeding sites in other areas include dirty stagnant water, and Lee and Woodhill (190) list their frequent occurrence in mud puddles of limited size. Larvae have been taken from both shaded and open situations.

A. tessellatus is a semi-domestic species, and adults were frequently collected in houses and cow sheds in India (67), and human bait traps in Malaya (125). Russell (253) in the Philippines collected resting adults only from under eroded, overhanging banks of streams, and in the damp, shaded cracks of an old stone wall. Lallemand et al, (183) observed for one specimen in the Netherlands Indies a flight range of about 1,100 yards. Although the females are known to feed readily on man, they are primarily zoophilic. Toumanoff (311) in Indochina found that only ten of 388 blooded females contained human blood. Mesnard and Toumanoff (216) reported less than one per cent positive for human blood, and Raynal and Gaschen (242) found that of 120 specimens none were human positives but 106 were positive for the blood of livestock.

Relation to disease. Apparently tessellatus is of importance only in Formosa where artificial infections with P. falciparum and P. vivax

were demonstrated. According to Weyer (335), 1.9 per cent natural infections were reported from Formosa by Anazawa. At Hongkong, China, Jackson (160) found one natural infection of 40 (2.5 per cent), and Marneffe et al (211) reported 1.96 per cent positive of 52 specimens. According to a compilation of data by Swellengrebel and Rodenwaldt (285), a total of 1,758 specimens collected in Sumatra by other workers were all negative for malaria. Soesilo reported one infection of 126 at Nias. In Java, Swellengrebel et al reported one infection (0.72 per cent) of 139, while a total of 387 specimens reported by four additional workers were all negative. It is not considered a vector in the Philippines. Manalang (209) reported negative results with 1,662 dissections.

Prawirohardjo (240) demonstrated by laboratory experiments that tessellatus may be a vector of Wuchereria bancrofti in Java.

Distribution. Anopheles tessellatus is a widely distributed Oriental species extending into the Australasian Region at the Moluccas. It ranges from Ceylon, India, Burma and the Andaman Islands extending into China at Yunnan Province and along the coast at Kwangtung Province including Formosa and Hainan Islands, and southward through Siam, Indochina, the Malay Peninsula and the Sunda Islands to Alor. It is widely distributed in Borneo, Celebes and the Philippines and extends into the Australasian Region at Halmahera, Boeroe, Ceram and Sanana. The records from the Moluccas may be confused in part with punctulatus.

Sources of Distribution Records.

Burma: 67.  
China: 61, 108, 109, 160, 162, 195, 204, 243, 245, 288, 336, 338, 345, J.H.  
India: 67, U.S.N.M.  
Indochina: 18, 42, 63, 97, 120, 122, 123, 126, 127, 128, 210, 211.  
Japanese Archipelago: 229, 232, 340.  
Malay Archipelago: 51, 53, 131, 165, 205, 226, 240, 285, 328, 329, 330, 334.  
Malaya: 133, J.H.  
Melanesia: 285.  
Philippine Islands: 144, 254.  
Siam: 19, 25, 30, 59, 278, J.H.



ANOPHELES (MYZOMYIA) VAGUS VAGUS Dönitz, 1902

Synonymy. Anopheles formosaensis II Tsuzuky 1902; A. indefinitus Ludlow 1904; A. flava Swellengrebel 1917; A. javanensis Swellengrebel 1920; A. rossii of Leicester 1908.

Systematic notes. This species is extremely close to subpictus but may be readily separated in the adult female by the palpal banding. In vagus the apical pale band of segment IV is much broader (3-5 times as long as the preceding dark band) than in subpictus (apical pale band same length or not more than twice as long as the preceding dark band). The close proximity of the outer and posterior clypeal hairs to the inner clypeals in vagus giving a characteristic bunching together of these hairs will distinguish the larvae from subpictus. In the Philippines, the typical species has been replaced by the subspecies limosus. According to Christophers (67), a white spot at the top of the female proboscis in vagus is absent in limosus. King (168) separated the larvae according to the position of the posterior clypeal hairs. In limosus these arise much further back on the clypeus and are nearly in line with the inner clypeals.

Bionomics. The larvae of vagus have been collected from a variety of situations, although typically they breed in the fresh water of small pools and puddles near villages. Other breeding sites listed were drains, borrow pits, domestic containers and hoof marks especially in the vicinity of villages, as well as grassy swamps and fallow or cultivated rice fields. According to Lee and Woodhill (190) the larvae are not found in brackish or salt water. Christophers (67), however, reported collections from brackish water at Bombay, India.

Although adults were frequently collected from houses, the females are strongly zoophilic in their feeding habits. In Indochina, Mesnard and Toumanoff (216) and Chedecal (63) demonstrated that only 3.5 and 2.7 per cent of the blooded females examined contained human blood, and all of 839 specimens were negative for Raynal and Gaschen (242).

Relation to disease. Experimental infections of vagus with Plasmodium vivax and P. falciparum ranged from 3.6 per cent to 26.3 per cent with many other negative results. Susceptibility to infection is low, and in view of its zoophilic feeding habits, vagus is not considered an important vector of malaria. According to a compilation of data by Swellengrebel and Rodenwaldt (285), one infection (0.04 per cent) was found in a total of 2,352 specimens collected in Sumatra. In addition, a total of 6,137 dissections as reported by other authors were negative.

In Java, only two or 0.09 per cent of 2,178 dissections were positive as reported by Swellengrebel and Rodenwaldt (285), Venhuis (327), and Soesilo (275). In Malaya, Gater (125) gave negative results for 2,219 dissections, and Covell (75) listed a total of 476 negative dissections by other authors. Although Toumanoff (314) found vagus to be the most abundant species in Indochina during the monsoon periods, natural infection rates were very low. Marneffe et al (211) found one (0.46 per cent) of 218 specimens collected in Tonkin to be naturally infected, although Gaschen and Marneffe (122) previously reported the low natural infection rate of 0.02 per cent for a total of 11,825 specimens collected in North Indochina. Toumanoff (307) at Tonkin found 0.07 per cent stomach and salivary gland infections of 2,625 specimens. In India, infection rates ranged from 0.018 per cent to 0.07 per cent. For a total of 23,017 dissections as reported by Covell (75), Weyer (335), Ramsay (241) and Russell et al (259), only four naturally infected specimens were found.

Prawirohardjo (240) at Batavia, Java, stated that vagus may be a vector of filariasis having found one specimen with infective larvae of Wuchereria bancrofti.

Distribution. A. vagus occurs throughout the Oriental Region extending from India and Ceylon, Burma and the Andaman Islands, Siam and Indochina northward into China at Yunnan Province and Hongkong including Hainan and Formosa. Southward it ranges throughout the Malay Peninsula and Archipelago including Borneo and Celebes extending into the Australasian Region at Boeroe and Ceram, and as an extension of the Lesser Sundas at Kisar and Babar. The typical form of vagus has been replaced in the Philippines by the subspecies limosus.

Sources of Distribution Records.

Burma: 67, 100.  
China: 61, 106, 108, 109, 160, 162, 195, 200, 243, 245, 288, 336, 343, 345, J.H.  
India: 67, U.S.N.M.  
Indochina: 63, 97, 118, 119, 122, 123, 126, 127, 128, 191, 192, 210, 211, 218, 313, 317, 318.  
Japanese Archipelago: 340.  
Malay Archipelago: 49, 51, 53, 165, 205, 240, 263, 285, 328, 329, 330.  
Malaya: 19, 132, 133, 143, J.H.  
Melanesia: 285.  
Siam: 19, 30, 59.



Systematic notes. Aedes togoi is a large distinctive species of the subgenus Finlaya. It may be confused with japonicus Theobald and koreicus Edwards, but is readily separable in that the white bands on the hind tarsus of togoi extend across the joints whereas in the other two species they are restricted to the basal parts of the segments. A. watesi Yamada (Japan) and A. seoulensis Yamada (Chosen) are distinguishable by the presence of patches of white scales on the anterior half of the mesonotum which are absent in togoi.

Bionomics. Edwards (83) reported that larvae of this species were collected from granite basins in Japanese cemeteries. Shtakelberg (267) reported larvae breeding in the foul rainwater of a stone cavity in a museum garden at Vladivostok. Montschadsky (220) stated that larvae have been found in brackish water pools in rocks which were within the range of the splash of breakers. He discredited Alektrova's record of a tree hole collection. Feng (110) described the breeding places as brackish water tidal pools along the coast. Ho (141) at Peiping recorded larvae from stone cavities containing fresh water, although Feng (110) stated that it is not known if the fresh-water larvae is the same as the brackish-water form.

Esaki et al (93) describe togoi as a common house mosquito in Honshu, Shikoku, and Kyushu where it bites at night in the presence of artificial light. In northeastern China the adults enter dwellings at

night and are serious pests in localities where abundant breeding occurs. In China it is more abundant along the coast than elsewhere. Shtakelberg (267) found it to be a pest in Vladivostok on warm evenings during late summers.

Relation to disease. Yamada (341) demonstrated the complete development of infective larvae of Wuchereria bancrofti in this species, and since it was found naturally infected, regarded it as a good vector of filariasis. According to Li and Wu (196), Jackson in Hongkong also observed the complete development of larvae. In areas where this species is abundant, it should be regarded as a potential vector of filariasis.

Distribution. The distribution of A. togoi is not very well known. It is described as common in Kyushu, Shikoku, and Honshu but rare in Hokkaido (Yamada (341)). It is reported to be rare in Formosa, and there is only a single record (Fusan) from Chosen. In the Ryukyus it is common in Okinawa and it was collected on Iwo Jima. On the Asiatic continent, togoi ranges as far south as Hongkong in China, and northward to Vladivostok and Birobidzhan of Siberia, Russia.

Sources of Distribution Records.

China: 93, 110, 196, 197, 341.

Japanese Archipelago: 83, 93, 197, U.S.N.M.

Korea: 341.

Siberia: 83, 220, 267, 268, 341, U.S.N.M.



AÈDES (STEGOMYIA) AEGYPTI Linnaeus, 1762

Synonymy. Stegomyia aegypti (L.), Stegomyia argenteus (Poiret) 1787, Stegomyia calopus (Meigen) 1818, Stegomyia fasciata (Fabricius) 1805, Aedes fasciatus (Fabricius), etc

Systematic notes. The lyre-shaped configuration of snow-white scales on the scutum is characteristic and sufficient for identification of the adults. There is some variation in the general coloration of aegypti but the characteristic marking of the scutum is always distinct. Three varieties have been recognized by Edwards (89): atritarsis Edwards 1920 (West Africa), luciensis (Theobald) 1901 (St. Lucia), and queenslandensis (Theobald) 1901 (Australia). However, the proper systematic status of these varieties still remains to be ascertained. The aegypti group of the subgenus Stegomyia is Ethiopian, aegypti being the only species found outside of the continent of Africa.

Bionomics. The biology of no other mosquito is better known than that of aegypti. The ease with which it can be reared experimentally, its great abundance in many parts of the world, and its medical importance has resulted in a considerable accumulation of knowledge concerning its biology. Aedes aegypti rarely breeds in earth-bound containers and uncommonly in leaf axils, leaves, bamboo stumps, tree-holes, coconut shells, etc. The vast majority of breeding sites are to be found in artificial containers such as rain barrels, earthenware pots, tin cans, glass containers of many types, roof gutters, cisterns, water tanks, wells, etc. Only a few cubic centimeters of water are necessary. It has been observed that with the destruction of artificial habitats aegypti may be forced to breed in earth-bound and vegetable situations. Water containing a certain amount of organic material seems to be preferred to clear tap water or extremely polluted water (Bonne-Wepster and Brug (39)). Breeding occurs almost without exception in the immediate vicinity of human dwellings, and larvae are rarely found more than 100 yards from a dwelling.

Eggs are laid singly on wetted surfaces, but can withstand prolonged subsequent drying. The first oviposition may contain up to 100 eggs, and a female can oviposit as many as 750 eggs during a period of two months. Fertile eggs are produced for as long as 30 days following copulation (with records of 37 and 62 days). Bonne-Wepster and Brug (39) have noted that certain conditions, such as the presence of yeast and bacteria, certain chemicals, adequate oxygen and agitation of water stimulate hatching. The duration of the larval stage depends quite naturally on the temperature of the water and abundance of food. It may be as short as five days, or as long as 40 or more days. Food consists of bacteria, protozoa, and certain algae. In the tropics the duration of the pupal stage is two or three days.

Copulation occurs soon after emergence. Virgin females suck blood as readily as fertilized ones. It is markedly anthropophilic although females have been known to feed upon other mammals and birds. The question of human racial preference is uncertain although according to Bonne-Wepster and Brug (39), O'Connor observed that whites were attacked more readily than colored individuals. This observation had been made previously by French investigators. Aedes aegypti is by preference a daytime biter seeking shady places, but will attack infrequently at night or in the evening. Adults are rarely found more than 100 yards from their place of emergence. Females in captivity have been kept alive as long as 100 days and males as long as 50. The life span under natural conditions is probably much shorter.

Relation to disease. The role of Aedes aegypti in the transmission of yellow fever is well known. Since this disease does not occur in the Pacific Area, further discussion of yellow fever transmission is unnecessary. The introduction of yellow fever into the Pacific Area however remains a potentially serious threat.

In spite of positive experimental infection data in other parts of the world, aegypti apparently is not an intermediate host of Wuchereria bancrofti (nocturnal or non-periodic) or of Wuchereria malayi in the Pacific Area. All experimental evidence in this area indicates that the larvae do not reach the infective stage.

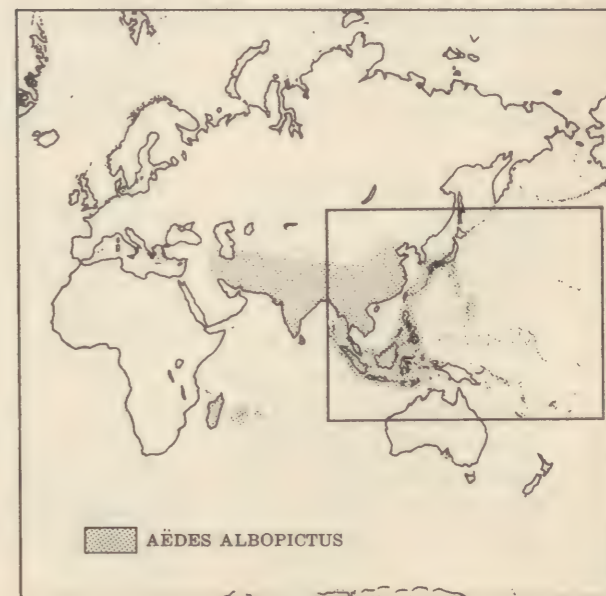
The investigations of Cleland et al (70) in Australia, and (according to Bonne-Wepster and Brug (39)) those of Sellards and Siler, Siler et al, Simmons et al in the Philippines, as well as those of Snijders and of Mertens leave no doubt as to its importance in the transmission of dengue fever. However this role is shared in the Pacific Area with albopictus and possibly with other species of Stegomyia such as hebrideus. The female apparently can be infected only during the course of the first two or three days of the disease in the human host. The incubation period in the mosquitoes is from 8 to 12 days.

Distribution. Although originally Ethiopian, this species has spread into all faunal regions wherever favorable tropical or subtropical conditions occur. This widespread distribution has been effected largely because of its domestic habits. The principal means of transportation has been sailing vessels and native craft in which the larvae breed in fresh water carried for drinking purposes. In the Pacific Area it extends as far north as Formosa and Ryukyus and westward throughout Melanesia, Polynesia, and Micronesia.

However, in many areas, such as parts of New Guinea, its distribution is restricted to localities where it has been introduced through sea or river traffic. Bonne-Wepster and Brug (39) found it in only two port cities on Ceram. In many island groups its distribution is limited to those visited by ocean traffic. For example, it was found on only two islands in the Society Group. Aedes aegypti is known to occur at altitudes of more than 3,000 feet.

Sources of Distribution Records.

Andaman Islands: 27, 29.  
Australia: 137, 289, 292, 293, 303, U.S.N.M.  
Burma: 27, 29, 303.  
China: 54, 104, 110, 198, 204.  
India: 27, 29, 301, 303.  
Indochina: 44, 45, 46, 47, 111, 278, 303.  
Japanese Archipelago: 93, 145, 179, 196, 217, 299, 303, U.S.N.M.  
Malay Archipelago: 40, 53, 134, 145, 199, 240, 262, 263, 266, 277, 278, 300, 301, 303, U.S.N.M.  
Malaya: 78, 145, 278, 299, 300, 301, 303, U.S.N.M.  
Melanesia: 11, 37, 40, 55, 86, 134, 138, 180, 248, 278, 290, U.S.N.M., J.H.  
Micronesia: 14, 55, 93, 94, 95, 145, 179, 217, U.S.N.M.  
Nicobar Islands: 29.  
Philippine Islands: 82, 145, 203, 303, U.S.N.M.  
Polynesia: 55, 58, 80, 88, 145, 213, 248, 300, U.S.N.M., J.H.  
Siam: 30, 59, 278, 303.



AEDES (STEGOMYIA) ALBOPICTUS (SKUSE), 1895

Synonymy. Stegomyia albopicta (Skuse); Aedes scutellaris (Walker) of many authors, Stegomyia scutellaris (Walker) of Theobald and others.

Systematic notes. Aedes albopictus, gurneyi Stone and R. Bohart, pseudoalbopictus Borel (Sumatra, Indochina, India), novalbopictus Barraud (India), subalbopictus Barraud (India), and flavopictus Yamada (Japan, India) form a very homogeneous group within the subgenus Stegomyia. In general they are indistinguishable externally, differentiation requiring an examination of the male genitalia. However, only albopictus is widespread and common, and of medical importance. The albopictus group of species is easily separated from the closely related scutellaris group in that the white markings of the thorax of albopictus tend to form patches, while in the scutellaris group there are longitudinal stripes.

Bionomics. The larvae of albopictus are found in many types of temporary water collections. Among the common breeding places are bamboo and tree stumps, tree holes, leaf axillae, coconut shells, and rarely in artificial containers, rock pools, ditches, etc. Larvae have been found in water ranging from pH 4.4 to pH 9.6 with a tendency towards favoring alkaline waters (Bonne-Wepster and Brug (39)). This species breeds in close proximity to human dwellings.

Aedes albopictus usually occurs out of doors although the females readily enter buildings for a blood meal. The females are markedly anthropophilic and are persistent and tenacious in their attacks. Most of the biting is done at twilight or in shady places during the day, and only upon occasion occurs after dark.

Relation to disease. The role of albopictus in the transmission of dengue has been well established by the investigations of Simmons et al in the Philippines, and by Mertens and Snijders in the Netherlands Indies (Bonne-Wepster and Brug (39)). Prior to this time the experiments of Japanese investigators in Formosa had strongly indicated a possible role in dengue transmission. Bonne-Wepster and Brug (39) considered it to be at least as important as Aedes aegypti in the transmission of dengue in the Netherlands Indies. It has also been assumed to be the important vector in Hongkong where it is common and where aegypti is rare. In Shanghai, dengue epidemics have been recorded where

albopictus occurs and where aegypti does not. This species also appears to be the important dengue vector in Formosa and Ryukyus.

Aedes albopictus apparently has no role in the transmission of filariasis since complete development of the larvae of either Wuchereria malayi or bancrofti has not been observed. Yamada (341) and others failed to obtain infective larvae in albopictus, and in other cases implication of this species has been presumptive.

According to Bonne-Wepster and Brug (39), Dinger et al demonstrated that albopictus can transmit yellow fever. Since the range of albopictus lies completely without the known range of yellow fever, this information is of importance in view of a future introduction of this disease into the Orient.

Distribution. Although originally a species of the Oriental Region, albopictus has expanded its range largely with the assistance of man. It has extended westward to Madagascar and Mauritius, eastward to New Guinea, Port Darwin in Australia, Saipan in the Marianas, and Hawaii, and northward into northern China, the Ryukyu Archipelago, and Japan. Apparently the introduction into Australia did not persist. The albopictus of Polynesia is due to incorrect nomenclature and is actually pseudoscutellaris or some other species of the scutellaris group.

Sources of Distribution Records.

Australia: 138, 298.

Burma: 28.

China: 54, 69, 76, 104, 110, 141, 147, 152, 184, 196, 198, U.S.N.M.

India: 28, U.S.N.M.

Indochina: 44, 278.

Japanese Archipelago: 93, 179, 184, 341.

Malay Archipelago: 40, 49, 51, 53, 134, 199, 240, 278.

Malaya: 132, 278, U.S.N.M.

Melanesia: 37, 134.

Micronesia: 130, U.S.N.M.

Philippine Islands: 82, U.S.N.M.

Polynesia: U.S.N.M.

Siam: 30, 278.



AÈDES (STEGOMYIA) HEBRIDEUS Edwards, 1926

Synonymy. Stegomyia sp. Laveran 1902; Aedes variegatus var. hebrideus Edwards 1926; Aedes scutellaris var. hebrideus Edwards 1932.

Systematic notes. It is possible that scutellaris (type locality, Aroe Islands) may be the same species as hebrideus reducing the latter to synonymy. This relationship cannot be determined until material from the Aroe Islands becomes available.

Bionomics. Larvae have been reported from various small collections of water such as in tree holes, coconut shells, rot holes, old bottles, old mollusk shells, shallow wells, etc. In the New Hebrides, Daggy (77) reported larval breeding in such artificial situations as the tops of steel drums, tires, sections of Quonset huts, corrugated sheet iron, tarpaulins and bomb crates, and in the axils of taro leaves. The adults are persistently anthropophilic and are frequently important as pests.

Relation to disease. According to Daggy (77), there is considerable epidemiological evidence implicating hebrideus as a vector of den-

gue fever in the New Hebrides and New Guinea. On several occasions dengue epidemics, unaccountable in the assumption of albopictus or aegypti transmission, have occurred where hebrideus was abundant.

Byrd and St. Amant (57) have reported natural infections with Wuchereria bancrofti in the New Hebrides. Of 377 dissections, 3.45 per cent were infected, in which the larvae of one specimen extended into the fourth day of development.

Distribution. Aedes hebrideus occurs from the New Hebrides to New Guinea and the Palau Islands. Collections have not been reported from the Solomons where it has been confused with quasiscutellaris. It is probable that hebrideus occurs in the Admiralty Islands, New Ireland and New Britain.

Sources of Distribution Records.

Melanesia: 55, 87, 187, U.S.N.M.

Micronesia: 164, U.S.N.M.



AÈDES (STEGOMYIA) PSEUDOSCUPELLARIS Theobald, 1910

Synonymy. Stegomyia pseudoscutellaris Theobald 1910; Aedes variegatus var. pseudoscutellaris (Theobald): Edwards 1926; Aedes scutellaris var. pseudoscutellaris (Theobald): Edwards 1932; Aedes variegatus and Aedes scutellaris of many authors.

Systematic notes. Farner and Bohart (98, 99) have aided considerably in elucidating the status of pseudoscutellaris in the much confused scutellaris group. Externally this species can be confused only with pernotatus of the New Hebrides from which it is not readily separable except by examination of the genitalia. However, pseudoscutellaris is not known to occur in the New Hebrides nor is pernotatus known to occur in Polynesia.

Bionomics. Larvae have been found in a variety of small water collections such as coconut shells, coconut husks, tree holes, cacao pods, open concrete drains, the hollow tops of coconut stumps, tin cans, rot holes in trees, holes in lava, tanks, etc. Adults are highly anthropophilic although they are known to attack other mammals. Biting occurs during the daytime especially on dull days and in deep shade. The flight range of the adults is extremely limited, seldom exceeding 100 yards. Adults are common in and around native villages. In the Marquesas Islands, this species has been recorded at altitudes up to 2900 feet.

Relation to disease. Since the investigations of Bahr (22) in Fiji, this species has been known as an important intermediate host of Wuchereria bancrofti (non-periodic type). O'Connor (230), Buxton and Hopkins (55), and Byrd et al (58) have adequately demonstrated that pseudoscutellaris is the only filariasis vector of importance in Polynesia (excluding Tonga). Furthermore, there is some epidemiological evidence indicating that pseudoscutellaris has a role in the transmission of dengue fever.

Distribution. This is strictly a Polynesian species extending from Tuamotu to Fiji (except Tonga) and northward to the Ellice

Islands and Tokelau. According to Farner and Bohart (99), the records of albopictus, scutellaris, and variegatus in Polynesia are referable to pseudoscutellaris. The records of pseudoscutellaris from New Hebrides and Guam are referable to pernotatus and guamensis respectively.

Sources of Distribution Records.

Polynesia: 55, 85, 87, 90, 230, 248, 302, U.S.N.M., J.H.

AÈDES (STEGOMYIA) TONGAE Edwards 1926

Synonymy. Aedes variegatus var. tongae Edwards 1926; Aedes scutellaris var. tongae, Edwards 1932.

Systematic notes. This species is apparently closely related to pseudoscutellaris. It differs from pseudoscutellaris in having reduced white bands on the hind tarsi.

Bionomics. Larvae have been collected from coconut husks, tree holes, and wells. The adults are known to attack man.

Relation to disease. It is assumed on an epidemiologic and geographic basis that tongae is the vector of non-periodic filariasis in the Tonga Islands.

Distribution. According to Buxton and Hopkins (55) and Farner and Bohart (99) this species is known only from the Tonga Islands.

Sources of Distribution Records.

Melanesia: 55, 87.

Polynesia: 55, 87, U.S.N.M.



CULEX (CULEX) QUINQUEFASCIATUS Say, 1823

Synonymy. Culex fatigans Wiedemann 1828. There has been considerable discussion concerning the synonymy of this species in regard to the identity of Say's type material. American workers however consider quinquefasciatus valid nomenclature while European entomologists continue to use fatigans.

Systematic notes. Culex quinquefasciatus belongs to the pipiens series which is principally African. The identification of quinquefasciatus in the Pacific area is not difficult except where its range adjoins or overlaps that of pipiens. In pipiens the basal bands of the abdomen are continuous with the lateral spots, while in quinquefasciatus the lateral spots are detached from the basal bands. However, these characters are not always distinct, and although male genitalia are more diagnostic there are intermediate forms where the distribution of the two species overlap.

Bionomics. Culex quinquefasciatus is the house mosquito of the tropical and subtropical regions of the world. The larvae are found in all domestic or artificial collections of water and in such places as flooded open cement drains, flooded latrines, overflow water from houses, ground pools, ditches, shallow wells, and rarely in tree holes and bamboo. Larvae are never found far from human habitations. The adults are intensely anthropophilic and possess a flight range of as much as three or four miles. In the tropics they have been recorded at altitudes as high as 5000 feet.

Relation to disease. As early as 1877 Manson demonstrated that Culex quinquefasciatus was a good intermediate host of Wuchereria bancrofti and a vector of filariasis at Amoy, China. More recently this was confirmed by Hu (146) at Foochow. It was reported to be an intermediate host on Kabaena (near Celebes) by Brug (51), on Java by Prawirohardjo (240), and in Tonkin by Galliard (111, 112). According to Neveu-Lemaire (228) it was demonstrated to be a vector in Australia by Bancroft, in the Philippines by Ashburn and Craig, and in India by Sunder Rao. However, it appears certain that the susceptibility of this species to infection varies greatly in different regions. The assumption that quinquefasciatus is the only probable vector of filariasis has precluded the investigation of other important vectors. Bonne-Wepster and Brug (39), for example, have shown that there is no consistent correlation between the geography of quinquefasciatus and that of filariasis. The investigations of O'Connor (230), Buxton and Hopkins (55), and Byrd et al (58) have shown that this species has little or no role in the transmission of filariasis in Polynesia.

Modern experiments have shown that quinquefasciatus is not a dengue vector contrary to reports in the earlier literature and textbooks.

Distribution. This species is worldwide in its distribution throughout the tropics and semitropics, although it may be rare or absent in sparsely populated regions.

Sources of Distribution Records

Australia: 137, 289, 292, U.S.N.M.  
China: 54, 69, 104, 116, 146, 152, 159, 184, 198, 204, 278, U.S.N.M.  
India: U.S.N.M.  
Indochina: 44, 47, 110, 111, 112, 278  
Japanese Archipelago: 74, U.S.N.M.  
Malay Archipelago: 40, 49, 51, 53, 134, 199, 240, 277, 278, U.S.N.M.  
Malaya: 78, 132, U.S.N.M.  
Melanesia: 37, 40, 55, 58, 72, 134, 138, 180,\*248, U.S.N.M., J.H.  
Micronesia: 164, U.S.N.M.  
Philippine Islands: 82, 203, U.S.N.M.  
Polynesia: 55, 58, 80, 88, 213, 248, U.S.N.M., J.H.  
Siam: 30, 278, U.S.N.M.

CULEX (CULEX) PIPIENS PALLENS Coquillett 1898

Systematic notes. In the Palearctic part of the Pacific Area (Northern China, Japan, U.S.S.R.) pallens replaces quinquefasciatus. The relationship of pipiens and quinquefasciatus is described in the above. Typical pipiens and pipiens pallens differ very slightly and many authors do not recognize it as a distinct form.

Bionomics. The biology of pallens is very similar to that of quinquefasciatus. It is known to be anthropophilic in its feeding habits.

Relation to disease. The investigations of Yamada (341), Hu and Yen (153), and Hu and Chang (151) demonstrate adequately that this species is a good intermediate host and vector of Wuchereria bancrofti.

Distribution. Culex pipiens is a holarctic species which has apparently been introduced into southern South America and into southern Africa. The subspecies pallens has been reported only from China, Japan, and California, U.S.A. (introduced).

Sources of Distribution Records.

China: 101, 110, 141.  
Japanese Archipelago: 184, U.S.N.M.  
Korea: 178.  
Manchuria: 110.  
Siberia: 225, 268, U.S.N.M.



Synonymy. Panoplites annulifera Theobald 1901; Mansonia septemguttata Theobald 1907; Panoplites seguini Laveran 1922.

Systematic notes. Adults of annulifera are very similar to longipalpis. Barraud (29) states that longipalpis is larger in size and of darker coloration. According to Bohart (33), the presence of fairly broad appressed silvery scales in the mid lobe of the scutellum are absent in longipalpis, and the thoracic integument of annulifera is yellowish in comparison to the brown coloration of longipalpis. The presence of definite round spots of white scales on the scutum distinguishes it from uniformis and indiana. The larvae of annulifera are distinct from other species in that the basal half of the antenna is dark and the apical half light.

Bionomics. The larvae of Mansonia species attach themselves to and puncture the air tubes of various aquatic plants by means of a specialized saw-toothed siphon. Breeding habitats for these species are therefore restricted to fresh water ponds, pools, backwaters, and marshes supporting an aquatic growth of suitable host plants. Bonne-Wepster and Brug (41) observed a very close association of the larvae with Pistia sp., but recorded Eichhornia sp. as a host plant as well.

Adults are strongly anthropophilic in their feeding habits.

Relation to disease. Bonne-Wepster and Brug (40) considered annulifera as an important vector of Wuchereria malayi in the Netherlands Indies. Kariadi (165) demonstrated that it is the vector of malayi at Martapoera, Borneo. According to Neveu-Lemaire (228), Iyengar reported natural infections of 26 per cent in northern Travancore, India, and believed it to be the principal vector of W. bancrofti. At Batavia, Java, however, Prawirohardjo (240) reported that of fifteen specimens none developed infective larvae of bancrofti.

Distribution. An Oriental species, annulifera is recorded from the Australasian Region only at New Guinea (Merauke). From India and Ceylon, its range extends through Burma, Siam, Indochina, and southward into the Malay Archipelago at Sumatra and Java, to Borneo, Celebes and the Philippines. Distribution records for the Malay Archipelago and Australasian Region are incomplete, and there may be confusion with longipalpis.

Sources of Distribution Records.

Burma: 26.  
India: 26, U.S.N.M.  
Indochina: 115, 278.  
Malay Archipelago: 36, 38, 41, 50, 53, 134, 165, 240, 277, 278.  
Melanesia: 37.  
Philippine Islands: 33, 82.  
Siam: 30.

Synonymy. Culex longipalpis Van der Wulp 1892; Culex annulipes Walker 1857.

Systematic notes. The adults of this species are very similar to annulifera although the larvae are distinct as previously discussed. It is separable from uniformis and indiana by the presence of definite round spots of white scales on the scutum. The larvae of these species are indistinguishable.

Bionomics. The larvae are associated with Pistia sp., but adults have been taken in large numbers where these plants are rare or absent.

Relation to disease. Bonne-Wepster and Brug (40) described longipalpis as an important vector of Wuchereria malayi. The complete development of malayi was observed by Brug and deRook (52) following artificial infection. At Dermajoe, Sumatra, natural infections of 1.2 per cent were reported, and many were found with infective larvae. These authors concluded that longipalpis was an important vector of malayi in Sumatra. According to Neveu-Lemaire (228), Jurgens designated this species as the intermediate host of malayi on the western coast of Celebes. Leicester found that the larval development of W. bancrofti was incomplete.

Distribution. M. longipalpis is widely distributed in the Oriental Region ranging from India, Burma, Siam, Indochina (Tonkin), southward through the Malay Peninsula, Sumatra, Java and in Borneo, and the Philippines (Mindanao and Mindoro). In the Australasian Region it was recorded from the Moluccas and Boeroe, New Guinea and New Ireland. Distribution records for the Malay Archipelago and Australasian Region are incomplete. Barraud (29) stated that records from New Guinea were doubtful, although this island was included by Lee (188). There may be some confusion with annulifera.

Sources of Distribution Records.

Burma: 26.  
India: 26, 29.  
Malay Archipelago: 36, 38, 40, 52, 53, 134, 165, 277, 278.  
Melanesia: 37, 134, 138.  
Philippine Islands: 33.  
Siam: 30, 278.



MANSONIA (MANSONIOIDES) UNIFORMIS Theobald, 1901

Synonymy. Panoplites uniformis Theobald 1901; ? Culex conopas Frauenfeld 1867; Panoplites australiensis Giles 1902; Mansonia marquesensis Dyar 1925; Taeniorhynchus uniformis of authors.

Systematic notes. The adults of uniformis are similar to other closely related species of the Mansonioides group but differ principally in the markings of the scutum. According to Barraud, the scutal scales of uniformis are arranged in longitudinal greenish stripes which are entirely absent in the very similar indiana. Definite round spots of white scales in the scutum are not present as in annulifera and longipalpis. The larvae are almost identical with indiana and longipalpis, but uniformis can be separated from annulifera by means of the antennae which are basally half dark and apically half light in the latter species.

Bionomics. Bonne-Wepster and Brug (41) listed the following plants which served as hosts for uniformis in Java: Azolla pinnata, Eclipta alba, Eichhornia crassipes, Hygrophila quadrivalvis, Hymenachne amplexicaulis, H. interrupta, Isachne miliaceae, Jussieua repens, Leersia hexandra, Lemna paucicostata, Nymphaea stellata, Adontella leptostachya, Oryza sativa, Pistia stratiotes, Salvinia natans, and Spirodela polyrhiza. According to Bohart (33) Pistia spp. are the preferred host plants in the Philippines. Hill (138) reported that uniformis was also observed from the mangrove swamps at Papua.

The adult females are anthropophilic in their feeding habits and are persistent biters, being active throughout the day and night. Feng (110) observed that the females will bite in the open as well as inside habitations, and that heavy rain will not prevent their flying into houses.

Relation to disease. Mansonia uniformis is known to be an important vector of Wuchereria malayi, and a probable vector of W. bancrofti. Feng (105) demonstrated the complete development of malayi within eight days of an infective feeding. Kariada (165, 166) considered uniformis the important vector of malayi in south Borneo, and other authors have demonstrated and conceded its importance in the Netherlands Indies. Feng (110) reported that it was a vector in China, but a less favorable intermediate host than Anopheles hyrcanus sinensis. Its importance as a vector of bancrofti, however, is doubtful although Esaki (93), Neveu-Lemaire (228) and others have reported laboratory infections. At Guadalcanal, Byrd and St. Amant (57) demonstrated that 90 of 385 specimens were infected with bancrofti, but only one of these developed infective larvae.

According to Li and Wu (197) Philip reported for this species the experimental transmission of yellow fever in Nigeria.

Distribution. The distribution of uniformis is widespread extending from Africa, throughout the Oriental Region, and into the Australasian Region. From India, Burma, Siam, and Indochina it ranges northward to Peiping in the eastern provinces of China, to include Formosa, Japan, the Ryukyu Islands, and the Philippines. Southward along the Malay Peninsula, it was frequently collected in Sumatra and

occurs in Java, Borneo, and Celebes. At Boeroe and Ceram, uniformis extends into the Australasian Region ranging from North Australia and New Guinea, including the adjacent Admiralty Islands and New Ireland to Guadalcanal in the Solomons Group.

Sources of Distribution Records.

Australia: 137, 197.  
Burma: 26, 197.  
China: 54, 69, 104, 110, 197, 198, 204.  
India: 26.  
Indochina: 115, 197, 278.  
Malay Archipelago: 38, 41, 50, 53, 134, 165, 166, 199, 277, 278.  
Malaya: 197.  
Melanesia: 37, 134, 138.  
Philippine Islands: 82, 197, 203.  
Siam: 30, 197, 278.

MANSONIA (MANSONIOIDES) INDIANA Edwards, 1930

Synonymy. Mansonia africanus Bonne-Wepster 1930.

Systematic notes. The adults are very similar to uniformis, and differ only in that the longitudinal greenish stripes of the scutum are absent in indiana. Definite round spots of white scales in the scutum are not present as in annulifera and longipalpis. The larvae are very similar to that of uniformis and longipalpis, and are separable from annulifera by the distinctive antennae of the latter species.

Bionomics. The breeding habitat is similar to that of uniformis, except that the larvae are known to breed on Pistia only. Adults are strongly anthropophilic in their feeding habits.

Relation to disease. Bonne-Wepster and Brug (40) describe indiana as a good vector of Wuchereria malayi. At Serajoe Delta in Java, Rodenwaldt (247) stated that with annulifera it is a very important vector of filariasis. Galliard (113) at Tonkin, Indochina, demonstrated the development of W. bancrofti to the infective stage under experimental conditions.

Distribution. M. indiana is probably restricted to the Oriental Region ranging from India, Burma (?), Siam, and Indochina, throughout the Malay Archipelago including Borneo. This range nowever is questionable since indiana may be confused with other closely related species such as uniformis. Bonne-Wepster (35) and Bonne-Wepster and Brug (40) have included the Upper Digoel River in New Guinea, although Lee (188) includes only North Australia as its only probable distribution in the Australasian Region. Its occurrence in the Philippines is questioned by Bohart (33).

Sources of Distribution Records.

India: 29, U.S.N.M.  
Indochina: 111, 113, 115.  
Malay Archipelago: 35, 36, 38, 240.  
Siam: 30.

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